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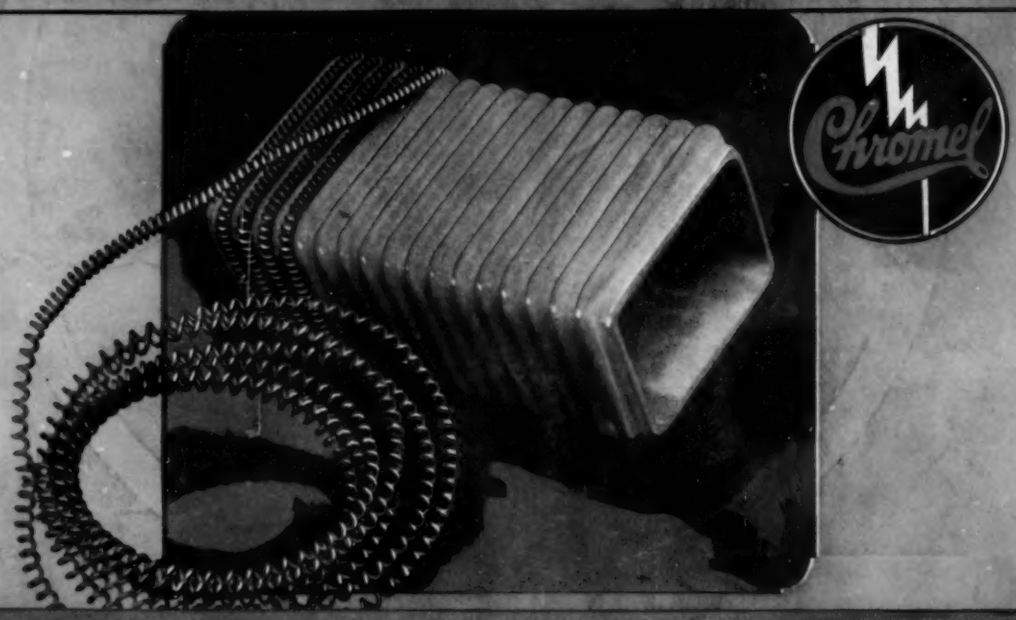

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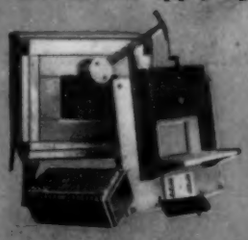

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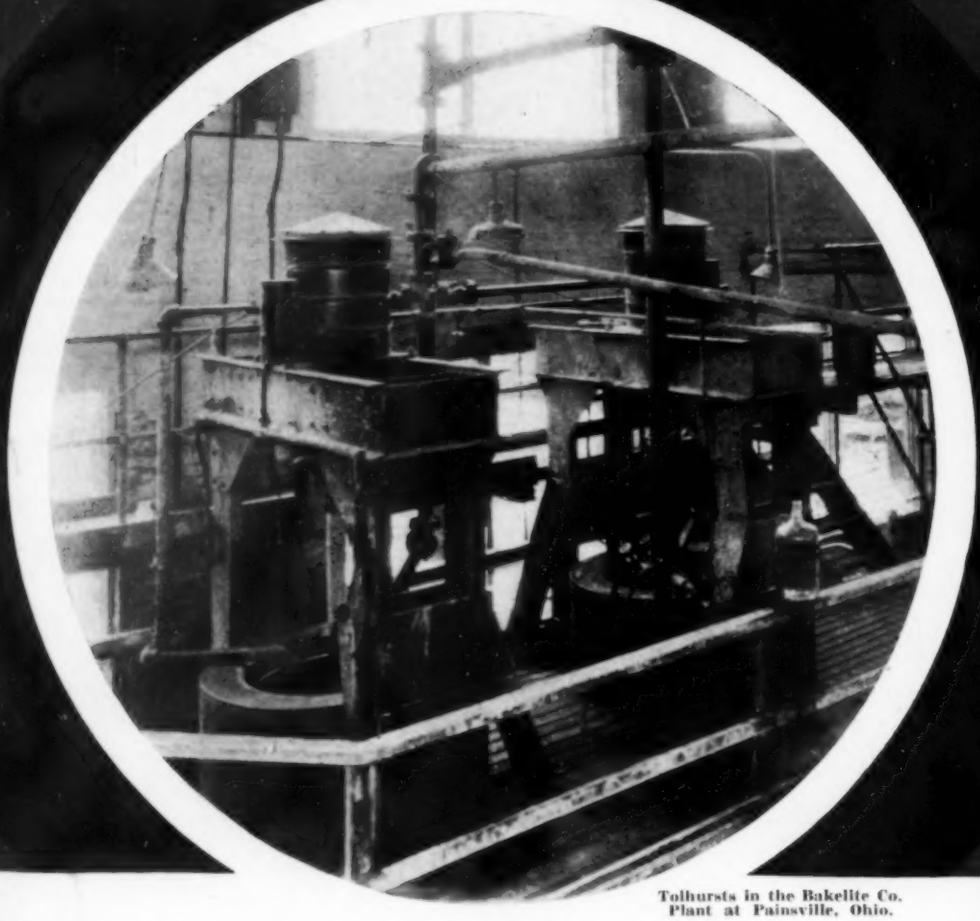

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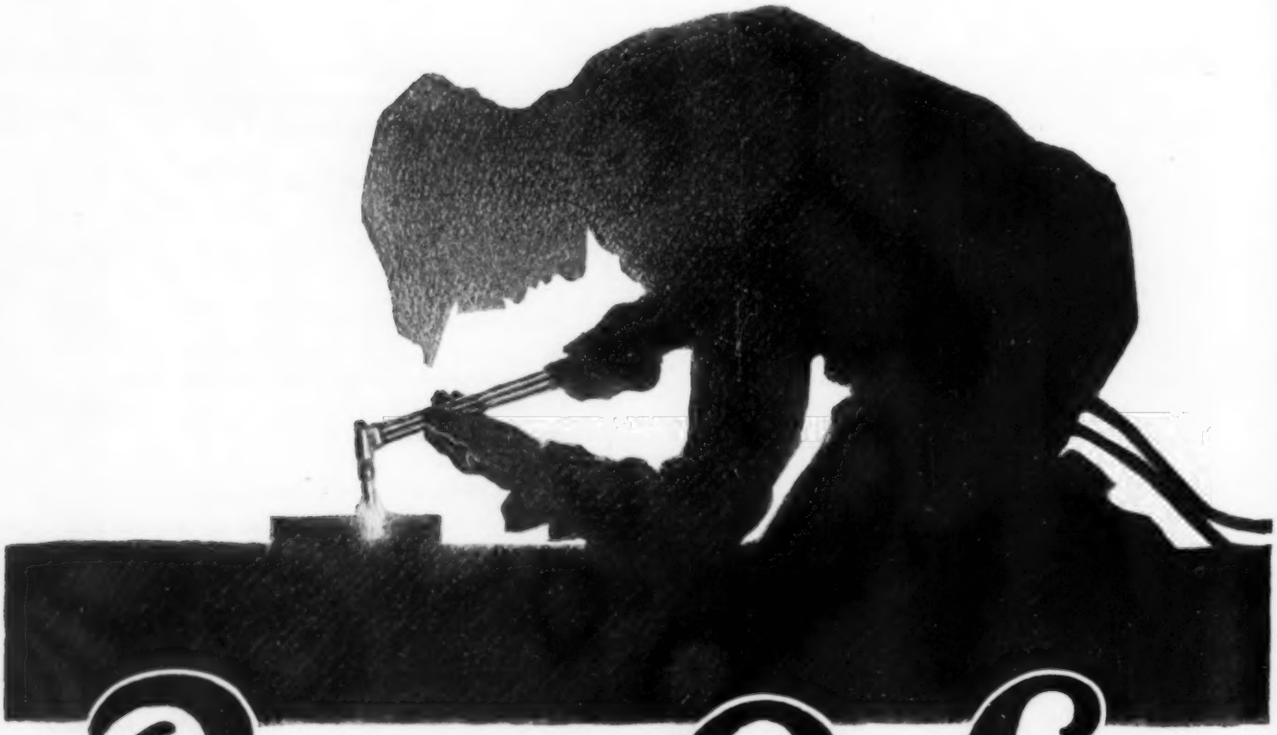

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CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE
Editor

Volume 34 — New York, September, 1927 — Number 9

Steam

Its Importance in Chemical Engineering

PROBABLY six million boiler horsepower is in use in American chemical engineering industries for the generation of steam primarily for process purposes—for cooking, boiling, distilling, evaporating, vulcanizing, sterilizing and general process heating. This is exclusive of steam required for power in these industries, whether that power be generated in the manufacturing plant or a central station. From this aspect steam becomes an important element of production in chemical engineering processes, for the transfer and application of heat to produce physical and chemical changes.

FURTHER evidence that steam, whether for process or power, is of pertinent interest to the chemical engineer, is found in the fuel requirements of the group of industries in which he is employed. They consume 39 per cent of the coal, 84 per cent of the coke, 46 per cent of the oil and 50 per cent of the gas used by all industry. Not all of this fuel is used for the generation of steam, but of the fuel burned under boilers these industries use three times as much for process steam as for power purposes. Altogether steam assumes a position of first-class importance in the work of the chemical engineer.

ALTHOUGH not usually responsible for the generation and distribution of steam for his processes, the chemical engineer should have more than a bowing acquaintance with a subject so closely related to his own operations. Indeed in the small plant the boiler room and equipment may come under his jurisdiction. In either event he is concerned with the efficiency of the steam plant and the economy of steam application because they vitally affect the cost of his process and product. Steam is one of his raw materials and he is just as much concerned with getting it cheaply and using it effectively as he is with any other cost-producing element.

STEAM economy probably has not received the attention it deserves from chemical engineers, nor always from plant managers. Discussion of the subject is usually pushed into the background because steam cost is only a small fraction of the total, and even a substantial reduction in this item would be insignificant in relation to the whole. But competition in American industry, domestic and foreign, is forcing producers to take advantage of every possible saving, however minor. It is the aggregate of these minor savings or wastes that makes profits or losses. Steam economy, therefore, and the means of accomplishing it are not to be ignored.

IN THE current issue of *Chem. & Met.* the reader will find a comprehensive review of the subject, from modern methods of steam generation to specific instances of steam application in chemical engineering production. At the Chemical Exposition during the week of September 26 the visitor will have an opportunity to study, among other chemical engineering equipment, various forms of apparatus for applying steam and economically controlling its use. By concentrating attention on the subject at this time through reading and observation, and critically surveying conditions in the plant, it is likely that opportunities for profitable improvement will be discovered.

Modern Aspects of the Use of Steam In

New developments, improved methods and great potential economies make the generation and use of steam of increasing import to the chemical engineer

POWER in many industries can best be supplied by central stations, what steam load there is (mostly for building heating) being generated entirely apart from the electrical energy requirements, in such quantity as needed. In such cases the engineering problems encountered are fairly simple and the most economical layout can be determined, following the best existing practice, without any difficult and complicated investigation.

But most chemical engineering industries present a different situation. In these industries it is common to find a sufficiently constant consumption of low- or high-pressure steam in the process to permit all or a large part of the electrical requirements of the plant being met by current generated from this steam.

The result is that many such industries find it more economical to generate in their own power plants the electrical energy needed to conduct their manufacturing operations, rather than to purchase this energy from central stations. By generating their current they are able to obtain it at a cost lower than that at which it can be purchased, except in a few favored locations.

Consequently, most chemical engineering industry plants have boiler plants of good size and electrical generating plants large enough to supply all or part of their power requirements. In a few cases it has even proved economical to generate more electrical energy than is needed and sell the balance to some outside consumer or distribution system.

The methods of operation and combinations of equipment suitable to provide both the steam and electrical energy needed by such a plant vary for almost every case that can be found. The possible combinations are great in number. Therefore it is a most difficult problem to design the steam and electrical generating facilities so that the maximum economy compatible with efficient operation of the manufacturing end of the plant can be realized.

Progress in the development of chemical engineering processes has caused a marked trend toward the use of higher process pressure, with the result that the required steam pressures are also often higher than in the past. Such high steam pressures used in process work have served to emphasize the economies

in electric generation that can be made by the industrial plant when high pressures are also used for that purpose. With these problems of high pressures have come other problems of piping and equipment, technology and operating methods to withstand these pressures. An entirely new technique is now developing to meet these high pressure problems.

Where the electrical load is extremely low or for some other reason it is not practical or economical to generate electric current in the plant, there is a distinct tendency to generate the required steam from gas-fired boilers, wherever fuel gas can be obtained at a sufficiently low cost. Boilers of this type can be made automatic in operation, and savings in labor and other items can be made that often more than offset the higher cost of the fuel.

The present condition of intense competition has stressed as never before the necessity for accurate cost data in industrial operations. This factor, along with improved process control, has given a great impetus to the metering and control of steam used in process.

Many processes of the direct-heat type produce much more heat than can be effectively used in the process. Often this heat is wasted up the stack and constitutes a burden of charge against the process that is a severe handicap. Waste-heat boilers, developed in the steel and cement industries, provide a means of recovering much of this heat. Many industries are adopting this equipment and effecting remarkable heat economies as a result.

Equipment new to the chemical engineering industries, such as steam accumulators, steam superheaters, air preheaters and automatic boiler control systems are beginning to be adopted. In many cases these devices are leading to remarkable economies and improvements in operation and are pointing the way to still further developments. Interest in the use and generation of steam is more marked on the part of chemical engineers than ever before. This interest is soundly based on an ever-increasing importance of the rôle of steam in the efficient and economical conduct of the chemical engineering industries.

IT IS with these facts and this general picture in mind that *Chem. & Met.* has brought together the articles that make up the main part of this number. Each of these articles has been prepared by an engineer eminently fitted by training and experience to deal with his subject. And the group of articles taken as a whole, covering the most important of the many aspects of the use of steam in the chemical engineering industries, should help to crystallize the importance of steam to the chemical engineer and emphasize those modern aspects of its use that will lead to improvements in the industries for which he is responsible.

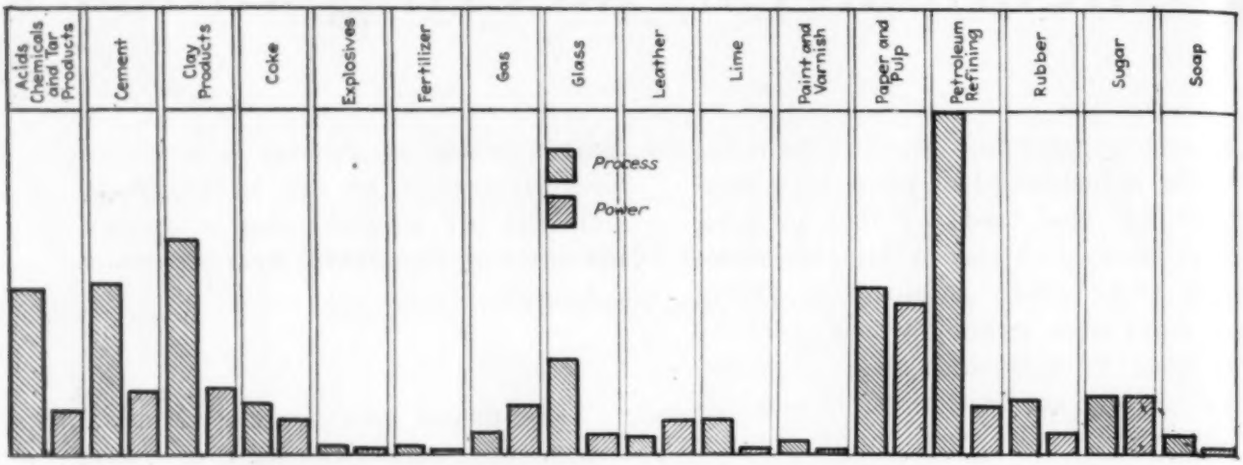


CHART I—Comparison of fuel used for process heating with fuel used for power generation in various chemical engineering industries. This comparison is made on a basis of B.t.u. heat content of all fuel used per year.

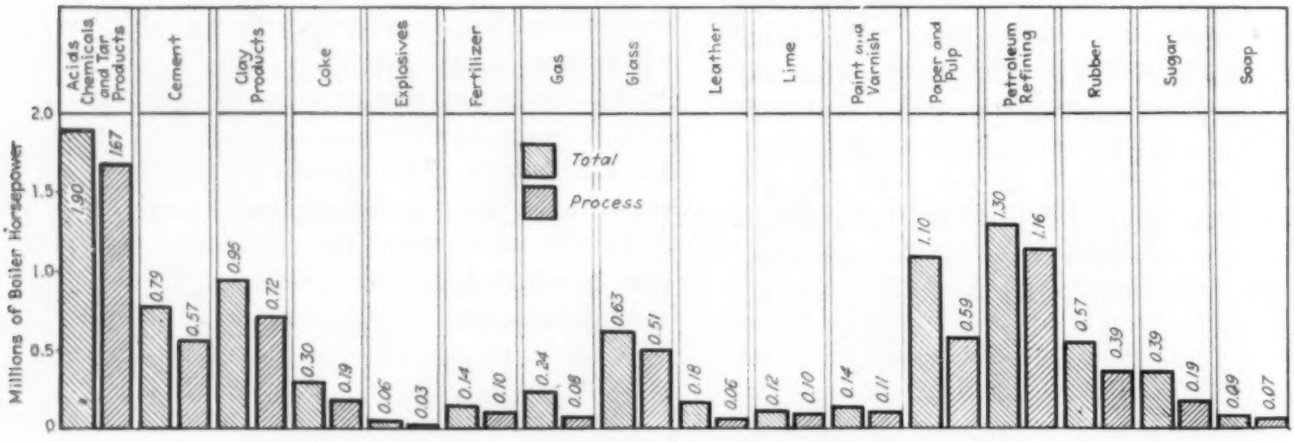


CHART II—Comparison of boiler horsepower equivalent to total fuel consumed per year with boiler horsepower equivalent to fuel used for process heating per year in various chemical engineering industries.

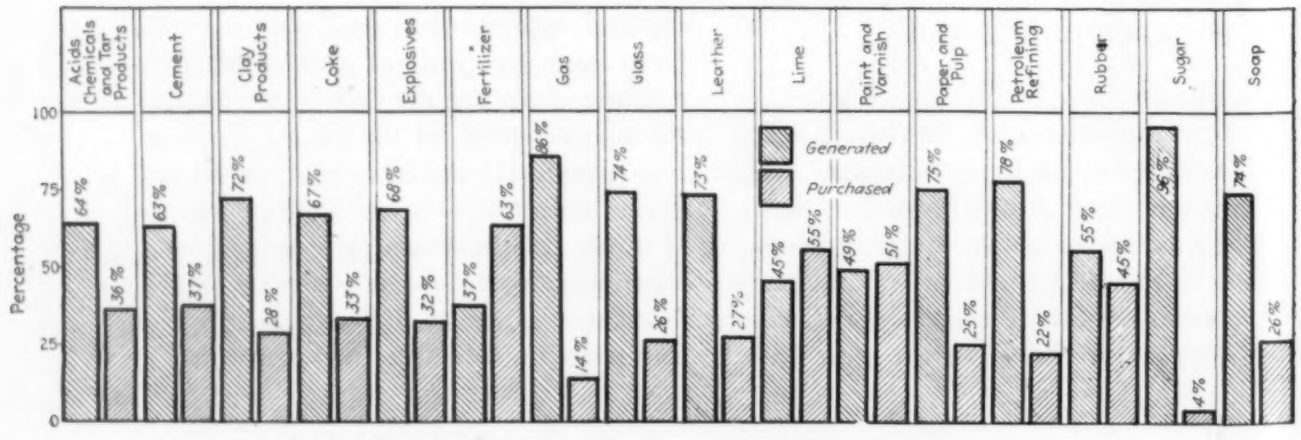


CHART III—Comparison between power generated at the plant and power purchased, in per cent of total power consumed, for various chemical engineering industries.

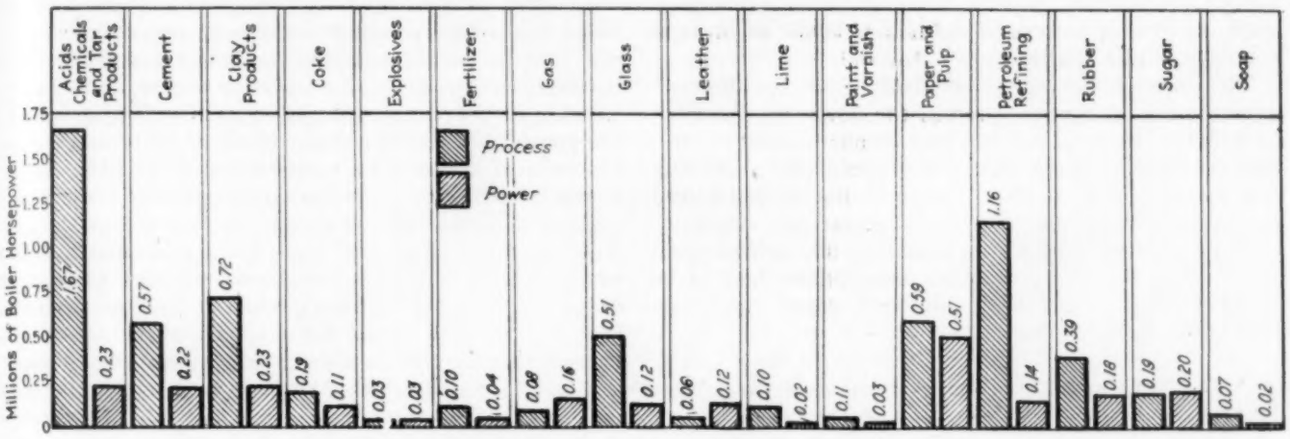


CHART IV—Comparison of boiler horsepower equivalent to fuel used for generating power with boiler horsepower equivalent to fuel used for process heating in various chemical engineering industries.

Use of Steam for Process Heating and Power Generation

STEAM is an important factor in the chemical engineering industries. In the manufacture of chemicals, dyes, drugs, pulp and paper, soap, sugar, rubber, wood products and food products steam as a means of process heating plays a major part. In other chemical engineering industries its use is of great importance.

Because of this, these industries are all concerned with the generation of steam and must all be equipped with steam generating plants. This being the case, it also is generally economical for these plants to have power generating equipment sufficient to supply their demands for electrical energy for the operation of production machinery and other moving equipment.

Chemical engineers need to know certain facts as to the use of steam and power in these industries. What proportion of the fuel used is used for process work and what for power? How do these industries compare as users of fuel, process heat and power? What proportion of the power is purchased power? These, and other similar facts are useful in any economic studies that may be made in the chemical engineering industries. Unfortunately this information is not available, nor are there any statistics obtainable from which it can be better than approximately inferred. The nearest approach to an answer to these questions comes from an interpretation of the census figures.

In his book, "Chemical Engineering Economics," Tyler says: "As power generation in industrial plants is only a part of the manufacturing operation, it is likely to be neglected, thus allowing waste to go unchecked, possibly for years. The experience of consulting power plant engineers shows that a 50 per cent reduction in coal consumption has been attained in many of the largest industrial plants, and without making extensive changes in the equipment.

"The first step toward increased efficiency is a survey of steam and power costs, after which a permanent system of record-keeping should be installed. . . .

"Whether to generate power at the plant or purchase it from the central station is perhaps the most common problem before the general plant engineer. As a rule, the primary generation of electric power by industrial plants will be neither profitable nor desirable." . . . But . . . "When steam is required primarily for process, however, electric power is generated secondarily and almost always at a big profit. Even inefficient industrial power plants can compete successfully with well-operated central stations, because most of the heat that the central station dissipates in condensing water is used for process work and heating in the plant. There is about 15 per cent transmission loss, furthermore, between the central station and the plant, and this, of course, is added to the price of power. In good non-condensing operation, about 20 per cent of the total heat of the steam is used by the engines; 40 per cent is absorbed in process equipment; 20 per cent is returned to the boiler as hot condensate; and 20 per cent is lost unavoidably, mostly by radiation."

Any general information as to the actual amount of steam used for process work or for power generation in the chemical engineering industries is extremely difficult to obtain. Figures gathered by the federal government give only the fuel consumed, primary horsepower installed and purchased power. Certain state government figures are more complete, but these show what happens in but a small part of any single industry. Questionnaires addressed to industry

bring but a meagre response, although some information obtained in that manner is helpful and will be brought out later in this article.

The only general figures available, then, are the government census figures referred to above and these figures form the basis of the four charts shown on preceding pages. These charts are useful in comparing one industry with another, but must not be considered as giving any factual information about any single industry. This is because in obtaining the figures from which they are plotted certain assumptions had to be made which may not be in line with actual conditions throughout each industry.

CHART I shows the relation of fuel used for process heating to fuel used for power generation. The census figures give the total amount of fuel consumed by various industries and also the primary installed horsepower. The fuel consumed was reduced to a common B.t.u. basis. Hours of work in each industry were obtained from government reports. The primary horsepower was reduced to an equivalent B.t.u. basis, assuming an overall conversion efficiency of 10 per cent and a load factor for each industry. It was assumed that all fuel not consumed for power generation was consumed for process heating, allowance being made for fuel entering into the final product, as in the coke and manufactured gas industries.

CHART II compares the boiler horsepower that could be produced from all the fuel burned (B.t.u. per year reduced to B.t.u. per hour) with the boiler horsepower that could be produced from all the fuel used for process heating (B.t.u. per year reduced to B.t.u. per hour). One boiler horsepower was taken as equal to 33,479 B.t.u. per hour. Quantities of B.t.u. per year in each case were obtained in preparing Chart I. It is to be noted that, in certain industries such as the manufacture of glass, most of the fuel used for process heating was used by direct firing and never converted to steam. Also, it is to be kept in mind that boiler horsepower figured in this way is a hypothetical quantity and bears no relation to actual installed boiler horsepower, figures for which are not available.

CHART III shows the relation between per cent of power purchased and per cent of power generated for the same industries shown in Charts I and II. Purchased power is given in the census figures. Power generated is obtained from installed power figures given in the census by the application of appropriate load factors. Being on a percentage basis the chart gives a fairly reliable picture of the relation of purchased power to generated power in the industries with which it deals.

CHART IV was developed from Chart II to show the relation of the boiler horsepower equivalent to power generated at the plant to the boiler horsepower equivalent to the fuel used for process heating. The latter quantity is the same as that which appears on Chart II, while the former is the difference between the two quantities on that chart. It must be noted that neither of these quantities represents actual boiler horsepower. Boiler horsepower, both in Chart II and Chart IV, is merely taken as a convenient unit to embody the hours of yearly work that prevail in the industry and to get away from the enormous numerical quantities involved if the B.t.u. consumed per hour were to be used.

It must be reiterated that these charts are only of value in giving a comparison between industries and do not purport to show actual quantities involved. For instance, in Chart IV, the bars for the sugar industry, if taken as representing actual quantities, might lead to the conclusion that the heating load could be carried by the exhaust steam from power generation. This is, of course, not the case. The bars in question do show, however, two things: first, that the amount of heat in raw fuel, consumed by process heating is approximately equal to the heat in raw fuel consumed for power generation at the plants, no account being taken of purchased power; and, second, that, while the sugar industry shows the balance noted above, as do also the explosives and paper and pulp industries, other industries show all the way up to 8 times as much heat in raw fuel used by process as by power, while still others show twice as much used by power as by process.

Inspection of the charts will lead to several general conclusions among which may be mentioned the following: Approximately 3 times as much fuel is used by this group of industries for process heating as is used for power generation. In most of these industries the greater part of the boiler capacity installed must be used for the production of steam used in process. And finally, about 75 per cent of the power required by these industries is generated at the plant, rather than purchased from outside the plant.

The relative importance of the industries studied as producers of power indicates that the engineers in charge of these processes should consider the generation of steam as one of the major functions of their plants. The operation of their steam generating equipment obviously bulks large in the final determination as to whether their plants shall or shall not run at a profit.

AS AN example of actual plant conditions, a manufacturer of dyes uses 96 per cent of the steam generated at his plant for process work, 4 per cent for heating the buildings and buys his full requirement of electric energy. Another chemical plant, with an average daily capacity of 1,000,000 lb. of steam in 24 hours, 7 days per week operation, generates its full power load. This plant uses half the live steam directly in process, one-quarter of the live steam for power generation and the remaining one-quarter of the live steam for operating pumps, compressors and auxiliaries. Two-thirds of the exhaust steam from the turbines, which run non-condensing, is used in the process and the remaining one-third is used for heating buildings and feed water.

A large fertilizer plant purchases the power needed, being in the vicinity of a source of hydroelectric power, the load being 7,000 kw. This plant uses but little steam, which is generated as needed, entirely separate from the power load.

A plant manufacturing explosives uses 19,000 lb. of steam per day for power generation, 4,000 lb. per day for refrigeration, and 4,000 lb. per day for compressed air. The steam used for process heating is 33,000 lb. per day. This is all live steam. The exhaust steam is used for feed water and building heating.

Another explosives plant, with a boiler plant having a capacity of 50,000 lb. per day, uses 13,500 lbs. per day in power generation and 18,000 lb. in process heating, under present operating conditions. This is live steam, the exhaust steam being only small in quantity, as the engines run condensing and most of the process steam is condensed in the apparatus.

In a medium-sized rubber factory all the process steam for vulcanizing is generated, along with the steam for building heating in low pressure boilers. The power load, 835 kw., is purchased. A large tire factory purchases 6,000 kw.-hr. daily and generates its steam requirements at 50 lb. pressure. This is used for vulcanizing and building heating.

In a linoleum plant, 200,000 lb. of live steam are used per day for power generation, 780,000 lb. per day for process heating, and 85,000 lb. per day for building heating. The exhaust steam load is 225,000 lb. per day for process work and 25,000 lb. per day for building heating. In addition, 7,000 kw.-hr. per day is the averaged purchased power. This plant also at times has some excess generated power which is fed back into the power company lines.

TWO large petroleum refining companies show somewhat similar characteristics. One uses 11,200,000 lb. per day of live steam and 1,300,000 lb. of exhaust steam for power generation; 9,800,000 lb. per day of live steam and 8,200,000 lb. of exhaust steam for process heating; and 450,000 lb. per day of live steam and 2,200,000 lb. of exhaust steam for building heating. This plant purchases no power. The other refiner uses 7,000,000 lb. of live steam per day for power generation; 89,000,000 lb. of live steam and 13,000,000 lb. of exhaust steam for process work, including pumping; and less than 1 per cent of total steam produced for building heating.

A large cottonseed oil refining plant uses 233,000 lb. of live steam and 35,000 lb. of exhaust steam daily for power generation. For process heating this plant uses 320,000 lb. per day of live steam, while 7,500 lb. per day of exhaust steam go into building heating. Besides the power generated, this plant purchases about 4,000 kw.-hr. of electric power daily.

The pulp and paper industry shows a wide variation in practice among the plants investigated. One plant, generating 750,000 lb. of steam per day, uses 485,000 lb. of live steam for power generation; 175,000 lb. of live steam and 200,000 lb. of exhaust steam per day for process heating; 75,000 lb. of live steam and 20,000 lb. of exhaust steam per day for building heating, and 15,000 lb. of live steam for auxiliaries. This plant purchases no power.

ANOTHER paper mill uses 150,000 lb. of live steam for power generation each day. This plant uses 85,000 lb. of the exhaust steam for process heating and heats the buildings with whatever of the remainder is needed (about 10,000 lb.); the rest of the exhaust being used in the low-pressure or condensing part of the turbines. This plant also purchases no power.

A large book-paper plant generates 5,300,000 lb. of steam per day. Of this 400,000 lb. are used in power generation and 4,200,000 lb. are used for process heating. In addition, 700,000 lb. are bled from the turbines for process heating at a pressure lower than the initial pressure. About 150,000 kw.-hr. are also generated for this plant daily by a hydro-electric station owned by the plant.

A plant manufacturing wrapping paper uses 900,000 lb. per day of live steam for power generation. This plant also uses about 1,000,000 lb. of live steam and 1,000,000 lb. of exhaust steam per day for process heating, part of the exhaust steam being bled from the turbines at a higher pressure than the turbine back-pressure. This plant purchases no power.

A plant manufacturing glass has 1,500 boiler hp. installed, producing 1,250,000 lb. of steam per day. Of this, 30 per cent is used for power generation, with 10 per cent low pressure steam also used in the mixed-flow turbine. The live steam process load is 25 per cent. Building heating takes 300,000 lb. of exhaust steam per day. Steam-driven equipment such as compressors and pumps uses 45 per cent of the live steam. No power is purchased.

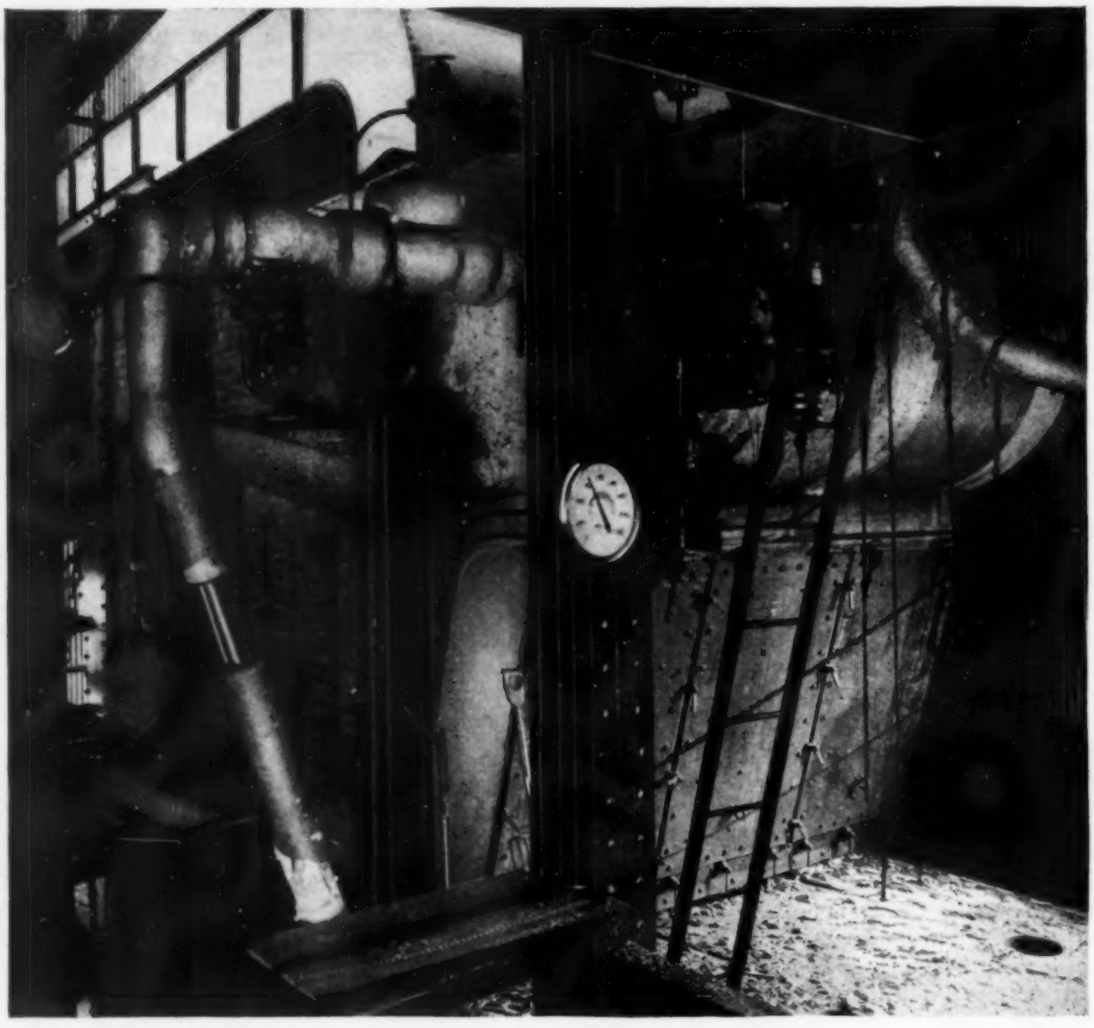
PERHAPS the clearest inference from these examples is the extreme diversity that occurs in steam and power generation and utilization in the chemical engineering industries. No two of these plants show the same set-up and it can be safely said that no two plants can be found in that whole industrial group that are the same. Such differences are as much a result of the lack of good engineering in these plants, as to power generation, as they are due to essential variations caused by the requirements of the industry.

However, there is one characteristic of practically all of these plants: they use a comparatively large amount of steam for process heating, with a somewhat smaller amount of steam used for power generation. It is this fact, coupled with the possibility of using the exhaust from the power units for process work, that gives the chemical engineer his legitimate interest in steam and power generation. If steam enters largely into his processes, then he must be concerned to see that it is produced at the lowest possible cost, as well as used economically. Since power can be generated at a low cost from the steam that is to be used at low pressure, he has the further opportunity of reducing the cost of his processes by getting the power to operate them at a low figure, as a byproduct, one might say, of the heating processes. Both of these economies can be attained only by starting at the boiler plant and, with as much care as would be used by the engineer of a central station, making sure that the generation of the steam and power is as economical as can be, allowing for the limitations of the particular plant.

HEREIN lies one of the greatest opportunities to be found today for cost reduction in the chemical engineering industries. Some few plants are obtaining both process steam and power at the lowest attainable cost, but such plants are indeed few. It is possible in almost all plants to make improvements in steam and power generation that will result in savings.

The articles that follow this cover the most important phases of steam and power production and many of the applications of steam, always with emphasis on economy. In addition, the two important trends of the day, that toward higher initial steam pressures and that toward automatic control of steam generation are discussed and their importance in industrial operations pointed out. The newest designs of equipment are discussed and the operation and utility of the latest devices for control are pointed out.

It is impossible to include in a brief survey of this nature, confined to one number of *Chemical & Metallurgical Engineering* all the facts relative to the generation and use of steam in the chemical engineering industries. The information presented, however, brings out the most important aspects of the subject and indicates the line of investigation that must be pursued by the chemical engineer who desires to reap the advantages of the economical generation of steam for process heating and power production.



High Pressure Boiler

for Process Steam

Evidence that extremely high steam pressures are coming into use in the chemical engineering industries, as well as in the central stations, is given by the boiler shown herewith. This is a 4,000-sq.ft. B. & W. cross-drum type boiler operating at 1,000 lb. pressure. It is used by the Mason Fibre Company, Laurel, Miss., which plant was described in *Chem. & Met.*, June, 1927. The high pressure steam is needed in converting sawmill waste into fibreboard.

Modern Trends in Steam Generation

By THEODORE MAYNZ
Consulting Engineer, Cleveland, Ohio

IF THE AVERAGE industrial manufacturing plant paid as much attention to its power and steam generating department as it does to its manufacturing processes, the usual boiler and engine equipment, design, and operation one sees even in modern plants, would be eliminated. There seems to be a rather general feeling among industrial executives that as long as the power or boiler plant runs, it is all right, never considering it a producing unit which must be made to pay, and in which depreciation and obsolesence are reflected in too high production costs.

Some modern industrial plants have only recently graduated from the line shaft engine, while most of them still have the slide valve engine exhausting against back pressure into atmosphere, low set, hand-fired boilers, sometimes dozens of them scattered around the plant, uninsulated steam lines weaving and sagging, steam and smoke belching from rusty stacks, and ash dumps half filled with "coke."

There are quite a few industrial plants that have hired or acquired power engineers, who have demonstrated to the management the error of their ways, and have modernized or built new plants that a central station would be proud of, and which have reflected their modernization in the lowered cost and increased reliability of power production. They are not the ones, however, that, when more capacity is needed, put in another boiler or engine, "just like the ones we've got" probably a 1900 or at best, a 1910 model. It is surprising how many plants have been installed rather recently, that would have been considered, by power engineers, obsolete fifteen or more years ago, but are pointed at with provide, by the management, as "our new power house."

IN INDUSTRY, as well as with public utilities, the power plant should be considered a department, whose costs of manufacturing, and gross and net earnings, should be known and controlled, just the same as in other departments. This is rarely the case, and even in well designed plants, the efficiency of operation is "all shot," due to lack of knowledge and intelligent supervision by the management.

To build a modern steam or steam-electric power plant, one cannot follow central station practice blindly, but one must know what such stations are doing and why. Even in central stations the design is extremely diverse for almost the same conditions, and this is not merely a matter of opinion of one set of engineers and another, but for definite and well considered reasons. One recent station uses pulverized fuel equipment, and another of similar size uses stokers. One uses 350 lb. pressure and another uses 650 lb. and a third uses 1,200 lb. One uses air preheaters and another uses economizers, while a third uses neither and a fourth uses both. All have definite and valid reasons for their particular design, worked up from carefully analyzed fundamental data.

The first step in re-vamping an old or building a new plant is to analyze the requirements. Due to a woeful lack of operating data, even the present requirements as to size and capacity are guessed at, let alone trying to prognosticate the future conditions. The only factor that saves most plants is the tremendous flexibility of power apparatus, especially the steam end. If it were not for this output range, many plants would have to pay dearly for their lack of foresight, not only in operating costs as many do now, but also in lost capital due to the necessity of scrapping undersized equipment. The simplest types of recording instruments are usually lacking, instruments which would allow the engineers to know and not guess the total, seasonal, daily and hourly load. An integrating watthour meter read once a month is useless for determining the hourly demand, just as useless as checking the coal pile once a month to determining the maximum and hourly steam consumption.

THEREFORE, unless adequate records are available for several years, designing or redesigning a power plant is purely a matter of guesswork. Assuming the total required capacity of a plant is known, what is the best and most economical method of producing this capacity? Engineering, like practically everything else, resolves itself into a question of economics. The finest of pure engineering is poor engineering, if it cannot be made to pay for itself. Only the simplest and most inexpensive apparatus can be economically installed in a six-month heating plant, while an eight thousand hour per year plant operating near capacity all the time can afford high investment cost for the conservation of fuel and the convenience of operation. Furthermore, if steam or electric power of the proper type can be purchased almost as cheaply as it can be manufactured, it would be foolish to tie up large sums of capital in a power installation, capital which no doubt could earn much larger returns if it were invested in the manufacturing process of the product which is being sold.

There is quite a difference in the fundamentals of design between the boiler plant that is used for generating electric current and one that is used for process steam. In the first, the design is tied up with the engines or turbines and their auxiliaries, which naturally complicates the problem, and in the latter no other considerations need influence the design but the generation of steam exclusively. We will first consider this simpler problem, the generation of steam for heat and process where no power is generated.

In this class of plant we can find about all types of apparatus, from hand-fired, cast iron, low-pressure heating boilers, to stokered or pulverized fuel boilers, de-

signed and equipped similarly to a base load central station boiler room. The size of the boiler in square feet of heating surface is an engineering problem dependent almost entirely on the daily or seasonal load curve. Boiler units can be designed to give their maximum efficiency at any desired rating, both by furnace and fuel burning design and by the use of various sizes of "economizer" section additions. Feed water conditions also affect the maximum output. Considering the boiler alone, the lower the rating, the higher the efficiency, this being entirely determined by the temperature of the escaping gases. However, a restricted grate (either hand-fired, stoker, pulverized fuel, oil or gas burner) will entail a sharp drop in the overall efficiency as the rating increases. A large grate will reduce the efficiency at low ratings and increase it at higher ratings. So we can change the shape of the efficiency curve for the entire unit and bring its maximum point at almost any desired rating, simply by a combination of type and size of grate. Furthermore the use of economizers and air preheaters tends to raise the efficiency of the unit at the higher ratings, as their heat recovery increases with the amount of the gases and their temperature. The use of high continuous ratings is detrimental to both the grates and furnace, even requiring water cooled surfaces in the furnace. With feed water using a large percentage of raw water make up, high ratings are dangerous, unless extreme care is taken in the water treatment. It is advisable therefore, to limit the maximum ratings to as low a figure as is possible, 250 per cent being the limit for industrial plant peaks in almost any installation, and 200 per cent maximum for most plants.

The type of boiler will also affect the overall economy at the higher ratings. In the horizontal water tube type, a high and narrow boiler, and in the inclined vertical type, a deep and narrow boiler will give lower flue gas temperatures and therefore higher efficiency than a wide boiler. Its draft loss is larger, and where chimney capacity is limited, cannot be used as well as the wide boiler. Furthermore, the narrow boiler is more adaptable to multiple retort underfeed and to chain and travelling grate stokers, especially of the forced draft type, where the extra length of grate gives the fuel the necessary time element for proper combustion. For pulverized fuel, especially with an all-refractory furnace, the wide boiler gives the required furnace volume without excessive height of setting. With single retort or industrial type of stokers, not being built in depths over 9 feet, the wide boiler is required to give sufficient grate area for burning the required amount of coal. Since the narrow boiler has shorter drums, and requires less brick work for equivalent setting height, it is considerably cheaper to install.

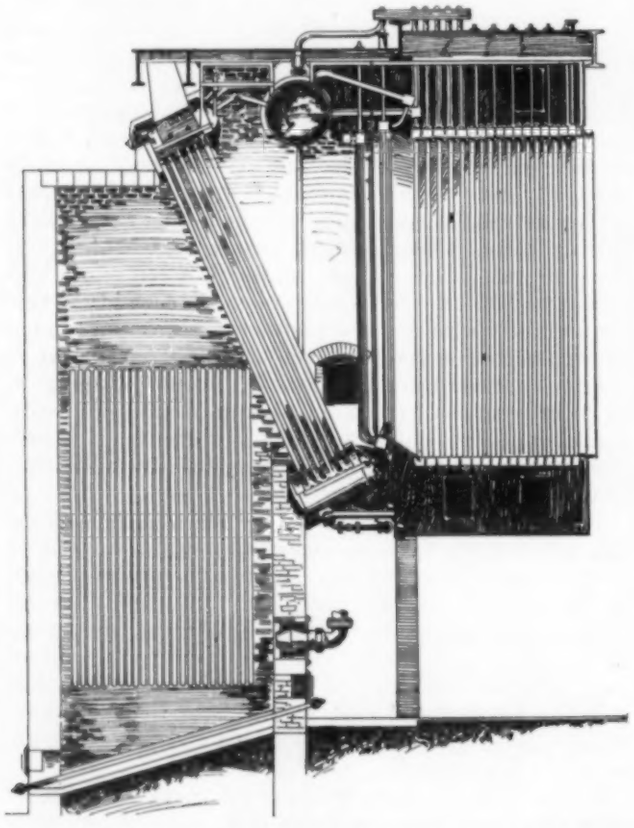


Fig. 1—Single-Pass Water Tube Boiler for Very High Ratings

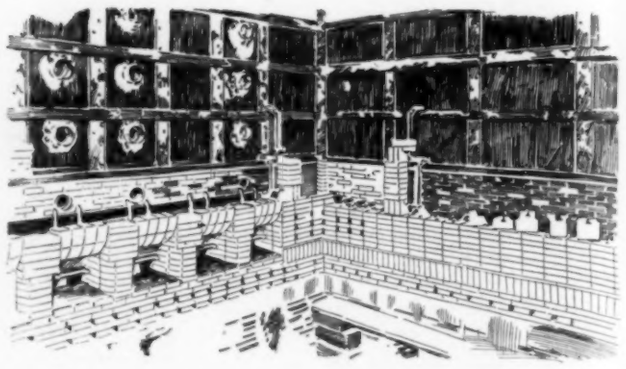


Fig. 2—Suspended-Type Refractory Boiler Wall in Course of Construction

Boilers. So much for the design end. There seems to be a tendency towards the use of three drum instead of four drum inclined vertical water tube boilers. Nearly all of the newer designs are of this type, with multiple rows of tubes between the connecting two drums. The designers claim not only dry steam, but also some superheat. Another design of three drum boiler combines a water cooled front wall section, which increases the tube surface exposed to radiant heat and also lowers the initial and maintainance cost of the setting. In horizontal water tube boilers, the cross drum boiler is by far the most popular. One manufacturer has brought out a two drum two pass fire tube boiler for which an efficiency equal to water tube boilers is claimed. The cost of this boiler is considerably more than an equivalent standard horizontal return tubular boiler, but the design eliminates a large quantity of setting, so that the installed cost is the same for both boilers.

For very high ratings, single pass boilers are available. These, of course, have both economizer sections and air preheaters, the boiler doing practically no other work except adding the latent heat of evaporation, this heat being mostly obtained from radiation and but little by convection. With pulverized fuel and all water cooled furnaces, "steam generators" are designed to give extremely high ratings, in which the boiler itself is only a comparatively small amount of the total heating surface installed in furnace tubes, economizer section, air preheater, and superheater surfaces.

Settings. The setting design and type is as varied as there are engineering ideas. All boilers are set higher than formerly, though one still sees some set in the good (?) old-fashioned way. There are three types of settings, the solid refractory, the air-cooled refractory, and the total or partially water-cooled setting. The solid

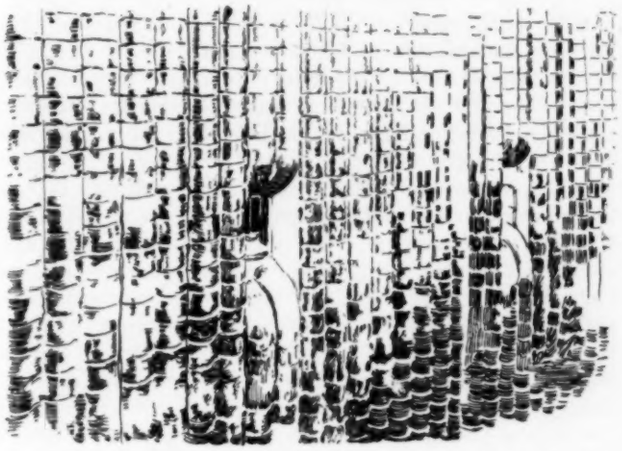


Fig. 3—Water-Cooled Boiler Wall of Steel Tubes Covered with Cast Iron Blocks

refractory settings are built in many ways. The standard red- and fire-brick type is the cheapest, but the 18 to 22½ in. all-fire-brick setting is by far more satisfactory for long life. Another type is the suspended-wall type, either solid or air-cooled, in which the lining is of tile, suspended on cast iron clips attached to the steel work of the boiler suspension. This is quite expensive, and only shows satisfactory returns where the units are operated at very high ratings for long periods. This type of construction is an excellent method for use in tying in the brick work in solid walls, and takes the place of relieving arches in front and side walls, permitting the replacement of the lower portion of the furnace.

The air-cooled refractory walls are mostly used with pulverized fuel furnaces, in which the secondary air is preheated, aiding combustion. The gain in efficiency from the utilization of this heat and the lowered maintenance of the walls more than pays for the extra cost, provided the ratings and hours of use are sufficiently large. There is a variety of methods of construction, the usual being of 9 in. of fire brick with an air space and then another wall, 9 in. thick, usually built of fire brick and insulating brick. The inner wall is bonded to the outer by tile, held in place by clips, zoning the furnace air space.

The water-cooled furnaces range from a water screen only, at the bottom of the furnace to chill the ash to prevent slagging, to all walls built of cooling surfaces. These surfaces are made of tubes, directly connected to the boiler circulation, the tubes being surrounded by cast iron blocks, or with steel fins welded on the sides, or with refractory cast into the iron blocks through which the tubes are threaded, so that the surface exposed to the fire is of refractory material. This latter wall, probably the most expensive to install, has the added advantage of maintaining high furnace temperatures at low ratings, thus insuring smokeless operation and good combustion under these conditions, not always obtainable with the other types of full-water-cooled furnaces. In fact, with most water cooled furnaces, only a portion of the furnace is cooled, part of the side walls and the front wall being of the usual refractory construction, the amount of water cooling being in the direct ratio to the minimum ratings. These surfaces will absorb about 50,000 B.t.u. per sq.ft. per hour, and thus, due to their absorption of almost pure radiant heat, are the cheapest heating surface, on an absorption basis, that one can use.

Water-cooled surfaces are now being used in conjunction with stokers as well as with pulverized fuels; and thus used materially raise the combustion rate for a given size furnace. Since a stokered furnace requires less space than a pulverized fuel furnace of equal heat capacity, the use of water cooled walls with stokers is more due to lowered maintenance than to the possibility of decreasing the furnace size.

Stokers. Nothing radically new has been developed lately in stokers. There has been a constant improvement in design, mostly toward lowered maintenance. Stokers are still designated by five distinct classes, each one serving specific purposes. The multiple retort, or central station type, either with steam operated dumps or clinker grinders, is still pre-eminently the high duty machine for most types of coals. Combustion rates of from 70 to 80 lb. of combustible per sq.ft. of grate area per hour are obtained, provided the furnace is adequate. Since they are now built in almost any desired length, these stokers are adaptable to nearly all conditions.

The industrial type of stoker, usually known as the single retort (though often built with two retorts, or with lateral retorts) is primarily used for boilers of about 400 hp. or less, especially where basement ash pits are unobtainable or not desired. Their maximum capacity of about 50 lb. of combustible per sq.ft. per hour limits them to lower boiler capacity, so that roughly for the same fuel consumption, 50 per cent larger grate area is required. As their maximum length is limited to 9 ft., and about 12 ft. in width, two stokers per furnace are required where upwards of 5,000 lb. of coal burned per hour is required.

The forced draft chain grate is also a heavy duty stoker, burning about 50 to 60 lb. combustible per sq.ft. grate area per hour, particularly adapted to very low fusing point ash coals, anthracites, coke breeze, and loads of fairly steady character. Though much more flexible in ratings than the natural draft chain grate, nevertheless they are not as adaptable to sudden demands as either of the underfeed types. Built in varying widths and lengths, they are easily adapted to all types and sizes of furnaces. Though sometimes installed with shallow pits, ease of operation really requires a basement for the ash removal.

The natural draft chain grate is being superseded by the forced draft, as the latter can be used to better advantage in nearly all cases. However, where the load is very steady, the coal non-coking, and high in ash, the

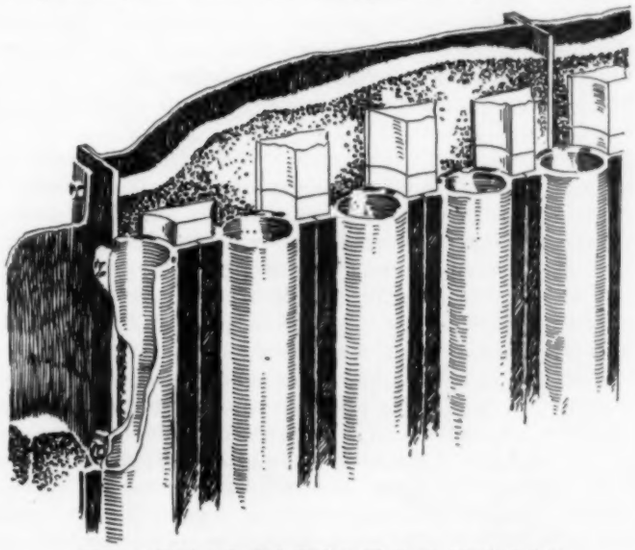


Fig. 4—Water-Cooled Boiler Wall of Steel Tubes with Fins Welded on Sides

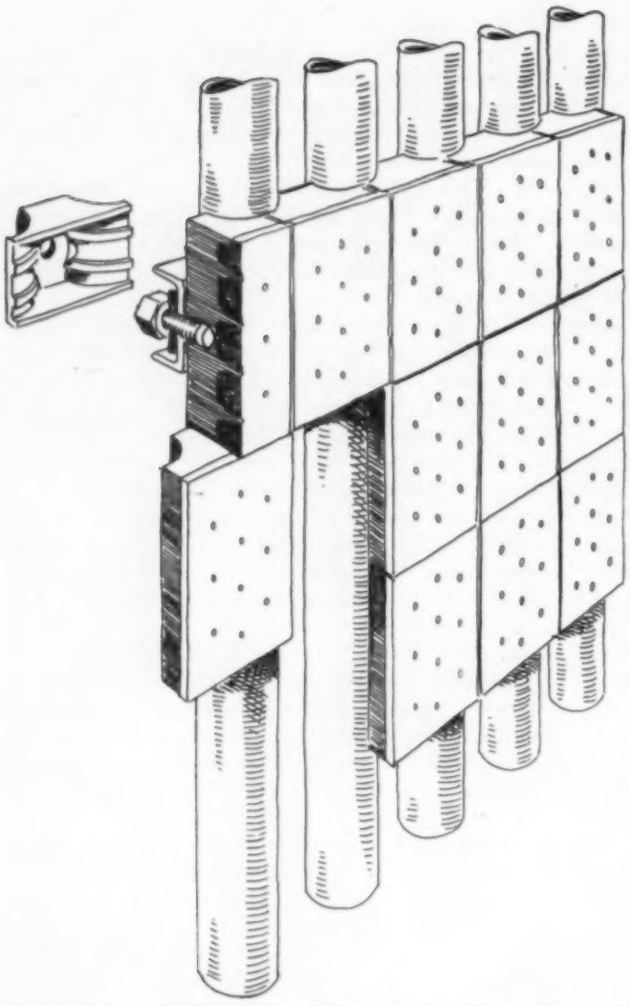


Fig. 5—Water-Cooled Boiler Wall of Steel Tubes Covered with Refractory Surfaces Cast into Iron Blocks Through Which the Tubes Are Threaded

natural draft stokers perform very well at ratings up to 40 lb. combustible per sq.ft. Beyond this point the ash pit losses are very high, and therefore, the efficiency drops off rapidly.

The inclined grate stokers, both straight and "V" type are rarely used except for very low ash high grade coals, at low rates of combustion, (35 lb. per sq.ft.) where their cleanliness and cheapness is a prime factor. Though they can be made to show high efficiencies, their operating results are, as a rule, but little better than well run hand fires, usually accompanied by high maintainance costs.

Pulverized Fuel. Pulverized fuel has been used to burn about everything that looks like coal, from anthracites to lignites, quite successfully. Its success is more dependent upon specialized furnace design than any other type of combustion equipment, and great care is required not only to provide sufficient furnace capacity, but to design the shape of the furnace so that all is used and adapted to the type of equipment.

The unit type mill, which embodies grinder, fan, separator, etc., in a single unit, has made great headway in the past few years. It is even invading the central station field, hitherto the exclusive property of the separate preparation plant type. The mills are of various types, impact, ball, screen separation, air separation, etc., and are now built in sizes large enough to operate boilers of over 1,000 hp. at over 300 per cent rating from a single unit. For ordinary coals no separate dryers are needed, but for high moisture coals, drying is imperative. For burning a maximum of 12,000 to 14,000 B.t.u. per cu.ft. of furnace, the solid refractory type can be used very nicely; for up to 18,000 B.t.u. water screens are necessary for most fuels; and for 20,000 B.t.u. per cu.ft. and over, hollow air-cooled and water-cooled furnaces are required. This applies to both types, unit and separate, as both are identical in combustion problems. They differ only in method of storage, the separate preparation plant using bins so that the grinders can be operated at maximum capacity, and therefore, lowest power consumption per ton of fuel, and the grinders can be designed for the average capacity, the peaks being taken care of by the pulverized coal storage. The unit system mill must be large enough to supply the maximum rating required, and as the power consumption increases rapidly with a reduction in capacity, their overall efficiency is reduced. However, with large boilers, several units per boiler can be installed, and can vary in capacity, so that the power consumption can be reduced, but never as low as the separate grinder plant. Furthermore, the bin system is more adaptable to wet coals, where dryers are required, and in very large installations is not only cheaper in first cost, but more flexible, both as to load, future expansion, and incorporating of improved developments. Also, the bin system is adaptable to space requirements, and as pulverized coal has been transported by pumps for more than a mile, the preparation plant can be entirely separate from the boiler room. The explosion hazard, with well designed equipment, is practically nonexistant. The main problem is to be sure that the cost of installation and operation will produce steam cheaper and better than the other method, a point that seems to have been overlooked in quite a few recent industrial pulverized fuel installations.

Preheaters. There are two types of preheaters, air and water; the latter being commonly known as an econ-

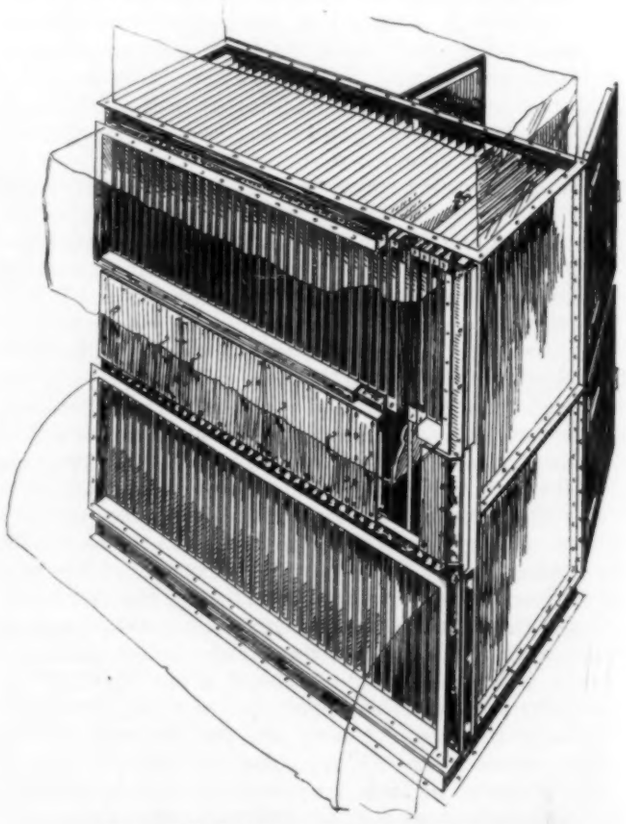


Fig. 6—Air Preheater of the Plate Type

omizer. Air preheaters have been used more lately in new central station layouts than economizers, because the former have worked out a better heat balance, when two or more stages of turbine bleeding are used. For the same degree of fuel saving, considering the boiler room alone, an economizer installation is slightly less expensive and takes up considerably less room, than air preheaters with heavily insulated air ducts. It is usually advisable to install some water cooled surfaces in the furnace if any considerable preheat of air is used. Since over 600 deg. F. of preheat has been successfully used with either pulverized fuel or stokers, this method of gaining efficiency has been removed from the experimental to the practical stage. Three types of air preheaters are used, the tubular, the plate, and the rotating, or Ljungstrom. As all air preheaters have both gas and air resistance, the forced and the induced draft fans and drive must be increased in size, while for economizers, only the induced draft fans are increased. The pressure drop through the water passages being relatively small, the feed water pumping power is only slightly greater, and no materially larger pump need be installed with economizers.

The steel tube economizer, either with cast iron rings on the outside of the tubes, or with lead-coated tubes, has displaced the old cast iron type, and since the steel tubes and the gas passages are smaller, they take up considerably less space. A steel tube economizer is about one-half as large as the same capacity cast iron one. Very often the economizer is built into the boiler and in the same setting, thus taking up less head room, but more floor space.

Auxiliaries. The turbo or high-speed fan has almost entirely displaced the slow-speed steel-plate type, and both motor and turbine driven fans are common. Centrifugal boiler feed pumps are used almost exclusively for capacities of 100 gal. per minute and over, usually directly connected to a steam turbine. Automatic soot blowers are almost universal, and are nearly all of the valve-in-head type, simplifying both the installation and operation. Feed water heaters of the deaerating type with vent condensers are not only more efficient from the heating side, but by the removal of oxygen and gases, prevent corrosion of piping and boiler surfaces. When economizers are used, the deaerating heater is a necessity. Feed water regulators have not changed much, being either of the variable level or constant level type. Used in conjunction with a constant excess pressure governor on the feed pump, the combination is an extremely reliable method for maintaining a safe and constant water supply for the boilers. The excess pressure governor is often built into the turbine driving the feed pump, taking the place of the usual constant speed governor.

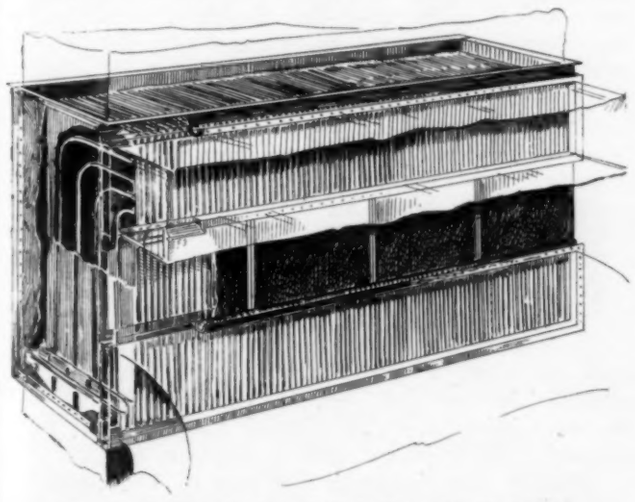


Fig. 7—Another Design of Plate-Type Air Preheater

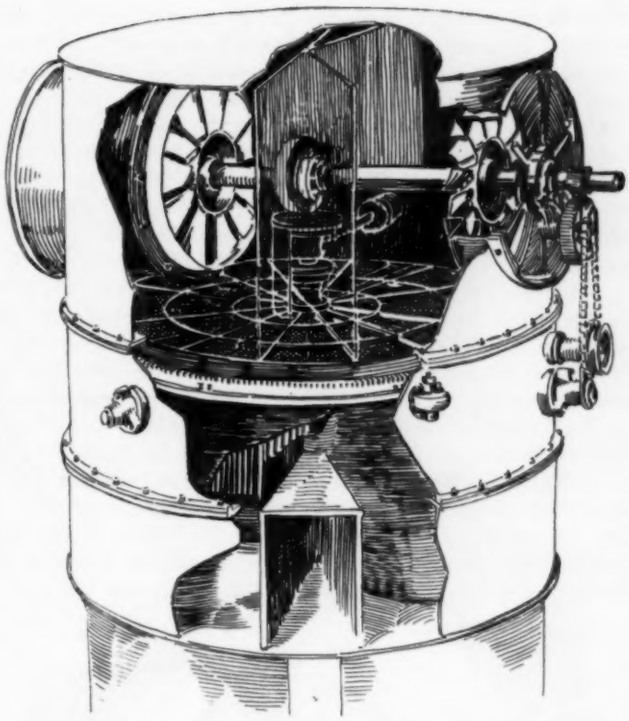


Fig. 8—Rotating Type of Air Preheater

Chimneys are still of masonry, concrete or radial brick for permanent plants, while cheaper plants of low power use the guyed steel stack, in spite of its high maintenance cost. The stream-line type of stack, with its divergent shape and built-in induced draft fan, is just coming to be used in this country, though common in Europe. Its low height, self-supporting construction, economy of power requirement, and relatively low cost, make it an ideal piece of equipment in many instances, and it will probably take the place of very many masonry and plain steel stacks in the future.

The brush-shifting, variable-speed, alternating-current motor is being used for fan and stoker drives, having about as great a speed range as a d.c. motor. One stoker manufacturer is furnishing a built-in turbine in the speed box of his multiple retort stoker, making the drive integral with the stoker, and requiring no extra room, floor space, line shafting, or chains, and giving a great variation in stoker speed.

Combustion Control. Most of the so-called combustion controls are very approximate, being pressure regulators, rather than controls, and are in no way capable of accurately controlling the boiler operation. They are, however, better than hand regulation, and do save considerable fuel. There are two controls, however, which really control all the conditions, one operating electrically from a flowmeter, and one mechanically. The former has operated some large pulverized-fuel boilers at practically test efficiency over a period of several years, while the latter has achieved quite similar results for a stoker-fired plant. They are very much more expensive than the usual type of control, and only pay their way when installed on comparatively large size units.

Coal and Ash Handling. The use and layout of coal

and ash conveyors is a special design problem, so tied up with the location of the plant that it is impossible to generalize on this equipment. The concrete or tile silo for coal storage has made great headway in the past few years, and in many cases gives the largest storage capacity per dollar of invested capital, for small or medium sized plants. Its adaptability to the various types of elevators and conveyors, small ground space, and ease of operation with practically no maintenance on the silo, has brought it to the front very rapidly.

Ash removal is still a nasty problem in most plants, and very few industrial stations can go to the expense of dumping the ashes direct from the hoppers to the railroad cars, or sluicing them into pits, as is being done in central stations. The steam jet conveyor, the drag chain, or very inadequate ash hoppers are usually installed. Where ashes are to be elevated into bins for removal by cars, the skip hoist is probably the most reliable and lowest in maintenance cost. Where basement ash hoppers are used, pivoted counterweighted gates, or power operated flat gates, all water-sealed, should be used; and the quenchers should be built into the brick lined hoppers.

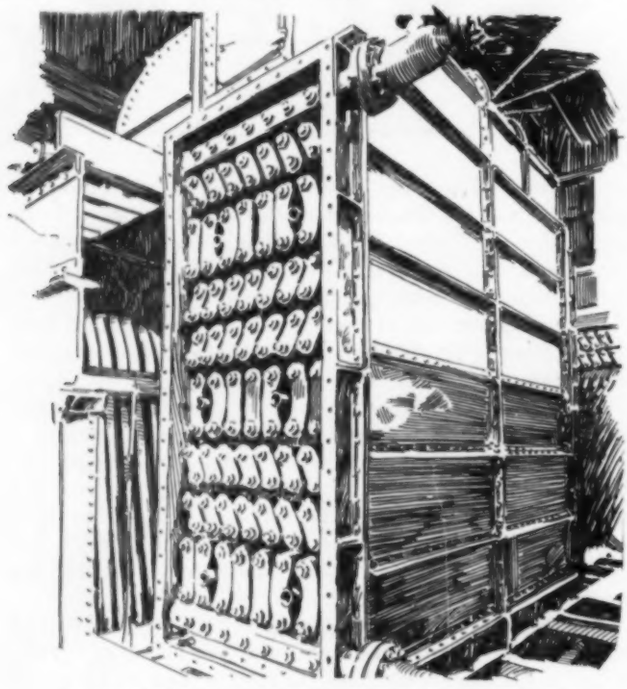


Fig. 9—Steel Tube Economizer with Cast Iron Rings on the Outside of the Tubes

These hoppers should always be designed for ample capacity.

Even with pulverized fuel, in spite of the general belief that all the ash goes out of the chimney, ample provision for ashes and their removal should be made. The use of one conveyor to handle both coal and ashes should never be allowed, as the maintenance is tremendously increased, and a breakdown both clogs the plant with ashes, and starves it for coal, making its operation a nightmare.

Weigh larries, and, for less expensive installations, monorail buckets and hoists, are used to weigh and distribute the coal, superseding the direct chute from the bunker or storage. A new chute, built on the segment of a cone theory, seems to have solved the poor distribution of fines and lumps, the former principal objection to chutes.

Piping. The piping layout and design can make or ruin a plant that is otherwise properly built. The use of Van Stone joints on pressures of 150 lb. and over, with superheat, will always pay, even with their high first cost. The welding of pipe is now so perfected, that most of the fittings can be eliminated, reducing the cost, even as compared with cast iron fittings; and also reducing the cost of insulating the flanges. The use of steel fittings for temperatures of 500 deg. F., and over, is quite necessary, and as these fittings are about three times as costly as cast iron fittings for equivalent pressure, welding shows even larger savings. Maintenance, if proper workmanship and care is used, is nothing, and changes and additions are easily incorporated. The use of steel valves without flanges, and with welding strip ends, so that the valve is welded into the pipe line, successfully eliminates even these joints. Bends replace elbows under

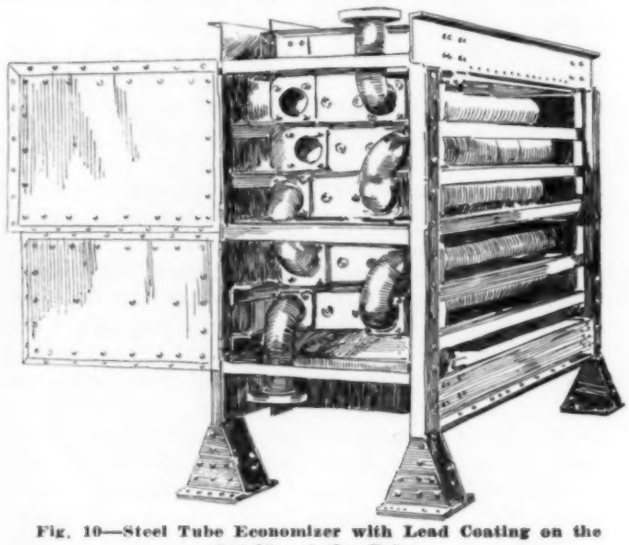


Fig. 10—Steel Tube Economizer with Lead Coating on the Outside of the Tubes

nearly all conditions, even in water and exhaust lines. Valves are not greatly changed, but the manufacturers are experimenting with steels to withstand temperatures in excess of 750 deg. F. without loss of strength.

Remote control for valves, either electric or hydraulic, is being used, and in some central stations all the main valves, such as those for cutting in and out of boilers, are operated by remote control from the operating gallery.

Feed Water Treatment. The day of compounds is about passed, as the up-to-date designers realize that a boiler must be kept absolutely clean to withstand the service that is now required, and that taking a boiler out of service entails a very considerable fuel and investment loss, especially for large units. To insure continuity of service, the feed water must be taken care of properly. The well-known types of soda ash-lime processes, both continuous and intermittent, hot and cold, are built in various forms, and are used about as universally as the base exchange, or Zeolite softeners. Both have advantages and disadvantages, and very often the choice is dependent upon other manufacturing processes more than the boilers, as for example in laundries and woolen mills. The internal treatment, as developed by Dr. Hall, seems to be very effective, and for small boiler plants, very much less expensive than separate softener plants; and is simple to operate. In all cases, it is advisable to take care of wet steam by special forms of dry pipes, which trap off the separated water, producing, under all but abnormal conditions, dry

steam to superheaters or process. It is a mistake to depend upon the superheater to remove moisture, let alone slugs of water, from the steam. Furthermore, wet steam is likely to be dirty, containing detrimental solids in suspension, causing erosion of valves, superheaters, and other equipment.

Superheaters. The only new design in this equipment is the radiant heat element, used either entirely, or in conjunction with the regulation convection type. These elements give an entirely different characteristic to the amount of superheat variation with ratings and CO_2. In this type, the superheat decreases as the rating increases, and increases as the CO_2 increases, and therefore, in combination with the proper number of convection elements, a constant degree of superheat can be obtained at all ratings and percentages of CO_2. These superheaters, being located in the furnace, also act in the same manner

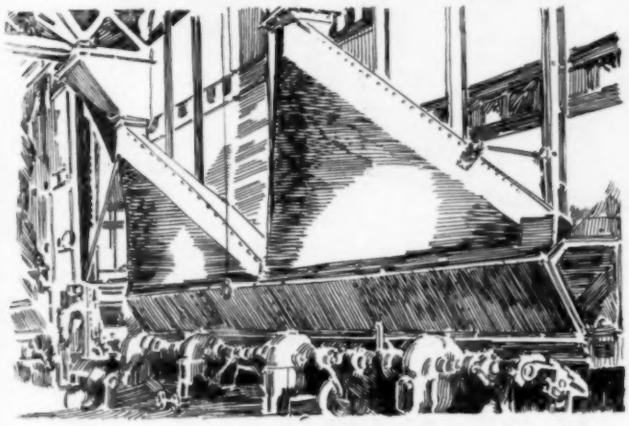


Fig. 11—Coal Chute with Chute Surface Shaped Like a Segment of a Cone

as water-cooled surfaces, protecting or replacing refractories.

Accumulators. Dr. Ruth's method and development of control, has brought the steam accumulator into the position of a working machine instead of an experiment. Their use is a matter of economics, as their savings must pay a return on the investment, which is naturally rather high. In some cases, however, they have been able to obviate the necessity of additional boilers, and in that way have easily justified their installation.

Waste Heat Boilers. The design of special boilers for waste heat installations has changed considerably. The use of high velocities is universal, entailing induced draft. Horizontal tubular boilers, single pass, with small diameter flues are being used considerably, making a very neat and compact installation. Close spacing and four and five pass baffles are used in water tube installations.

Generating Equipment. The use of high back pressure turbines is increasing, so that some plants generate all or part of their electric current at so low a heat consumption that it is practically negligible. As these machines are usually governed by the back pressure, they are almost entirely automatic in regulation of output. Back pressures of over 100 lb. have been used, but due to the small heat increase at high pressures these units have abnormally high water rates, unless extremely high initial pressures are carried, 600 lb. or even higher.

The una-flow engine, operating non-condensing, in sizes of 400 kw. and smaller, is extremely economical and is probably the best type of unit to use in conjunction with low back pressure process steam. Where pressures on process steam from 10 to 25 lb. are required and condensing water is available, either natural or spray pond, the bleeder turbine shows excellent results. The low or mixed pressure turbine is so well known, that its field of usefulness need not be discussed.

It is usually very difficult to balance the power requirements with the use of exhaust steam, so that the excess exhaust must be economically used rather than wasted to atmosphere or sewer. The use of air preheaters and pulverized coal driers operated by exhaust steam offers a solution. Operating the main generators at 100 lb. back pressure, and using their surplus exhaust to run the boiler feed pumps, steam driven fans, etc., will often improve the heat balance, and also reduces the initial cost of these auxiliaries and their piping.

Multi-stage turbines in small sizes are now being built, so that high economies can be obtained. They are naturally very expensive, but it is surprising how great an investment expenditure is permissible if the operating costs are correctly calculated and capitalized.

Condenser design has improved, so that extremely

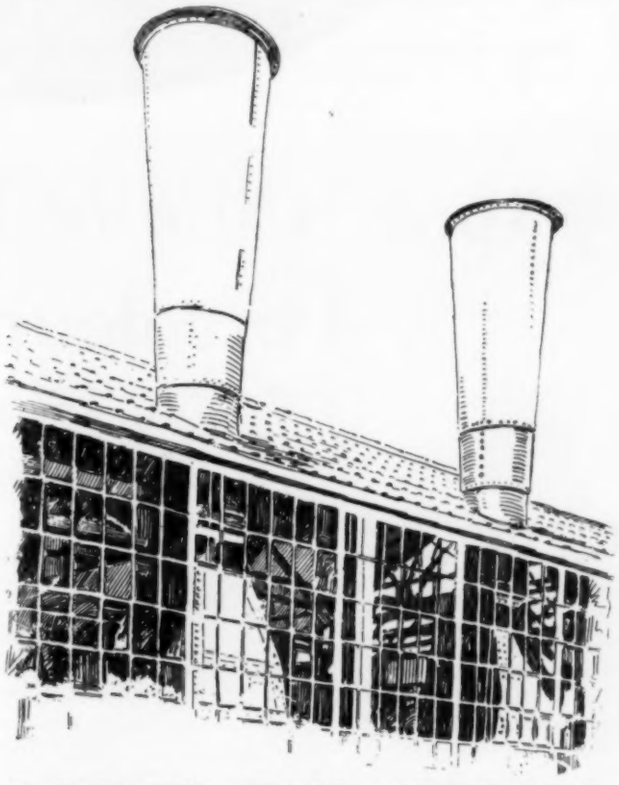
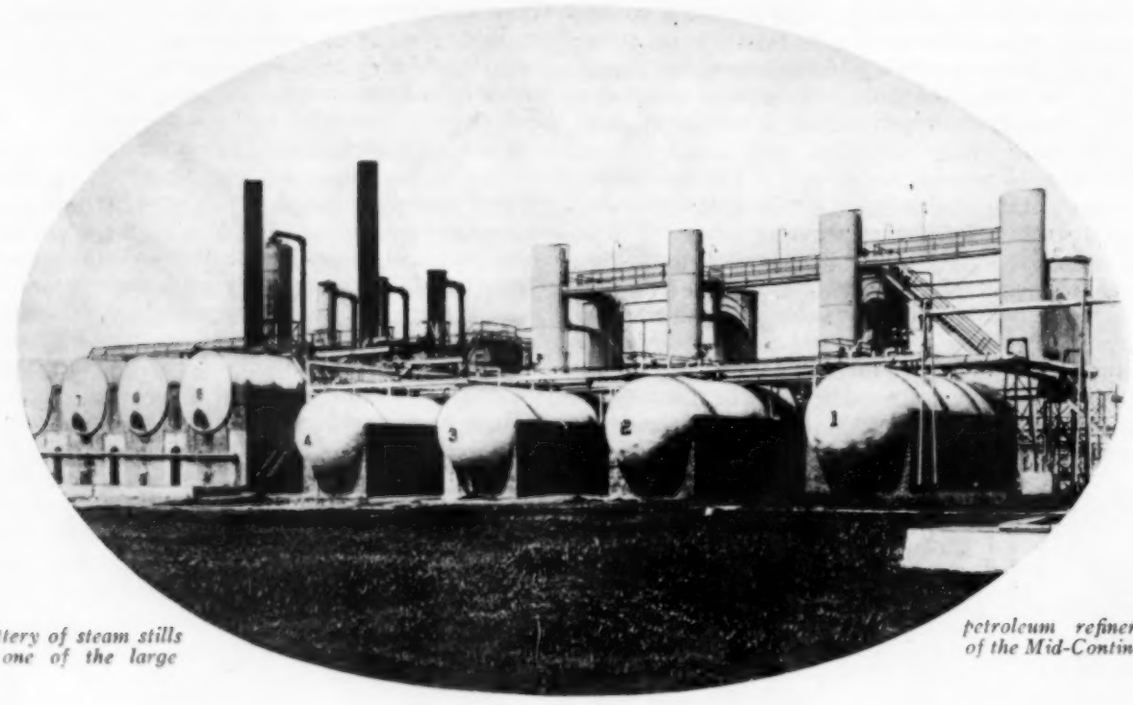


Fig. 12—Stream-Line or Venturi Type of Power-House Stack

high vacua are obtainable. The latest designs are particularly free from condensate refrigeration. Vacuum pumps of the steam jet and the hurling water types are now extremely efficient and reliable so that now one rarely sees a rotative vacuum pump in modern plants. Circulating and condensate pumps are refined, but about the same as heretofore. Separate drive for each condenser auxiliary is much more economical than a combined drive and is practically universal.

In a survey of the entire field of steam power generation refinement and better engineering is the trend and there seems to be no new discovery or invention which promises to revolutionize the manufacture of power and make necessary the wholesale scrapping of modern, well designed and engineered plants with consequent losses of investment and time.



Battery of steam stills in one of the large petroleum refineries of the Mid-Continent

Application of Process Steam in Petroleum Refining

By A. G. Peterkin, Jr.

Development Engineer, The Atlantic Refining Company, Philadelphia, Pa.

STEAM has been the handy-man around the refinery; today it is being limited to its proper economic field, and much effort is being expended to insure its efficient use in that field.

The enormous consumption of steam under the older methods meant large boiler installations, and since efficient ones could be purchased and erected without delay, unit steam costs were in general comparatively low throughout the industry. The aggregate expenditure, however, was and still is the largest single item of the cost of refining petroleum, and, considering all finished materials, is of the order of one-quarter of the operating expense. For every gallon of crude oil processed to finished products, more than a gallon of water has been converted into steam.

This steam has been used for the following purposes:

(1) Pumping oil and water.
(2) Heating oil in storage and process (condensing in closed coils).
(3) Simultaneous agitation and heating by direct injection into the oil.
(4) Distillation of oil at temperatures below the boiling points by direct injection into the oil, the heat being supplied in some cases by the steam itself, and in others by oil, coal or gas fire.
(5) Refrigeration for wax removal.
(6) Production of electric power.
(7) Miscellaneous uses, scavenging apparatus of flammable vapors, blowing out lines, fire protection, etc.

The use of electric or other power has been comparatively small. This practice has resulted in the waste of large quantities of heat in the form of exhaust steam, since, due to the rapid growth of the industry, the requisite lay-out and design for the greatest possible useful condensation have not existed.

THREE main factors govern the attempt to rationalize the use of steam in petroleum refining:

(1) The total amount of steam necessary for heating which can be converted to hot water, and the percentage of such heating which can be accomplished by steam delivered at a pressure substantially below the boiler pressure carried, i.e., exhaust from pumps and other machines.
(2) The amount of steam necessary in processes where its use is imperative and therefore noncompetitive, and the percentage of this consumption which can be supplied by exhaust.
(3) The cost of electric power generated by steam, as compared with central station, Diesel or gas engine generation, and if cheaper, the quantity of such power required.

The amount of low pressure or exhaust steam, that can be consumed is an important factor. Using heating equipment as the condenser, simple and inexpensive pumps, for example, may be run with a minimum quantity of steam, and will usually prove less costly to install and operate than with any other form of power. Heating absorbs a considerable percentage of the total power consumption of a refinery—of the order of one-quarter—and the greater part of the heating can be done with steam at a pressure as low as 10 lb. This outlet for machinery exhaust, however, is diminished by the severe seasonal fluctuation of temperature. The temptation is always present to over-estimate a refinery's demand for steam.

The largest "imperative" use of steam for processing has been in distillation.

Low pressure "open" steam is used to advantage in the continuous distillation (in packed towers, for example) of the lighter naphthas, where the heat is supplied by the steam and the amount required as a vehicle for the vapors is comparatively small. The wide introduction of the "bubble tower" type of fractionating column has reduced the amount of this re-running, since a greater quantity of salable naphtha is by this means produced directly from the crude oil.

In so-called "steam and fire" distillation (batch) the partial recirculation of steam by the use of high pressure steam and injectors has been practiced for many years. By the use of well designed injectors and condensing equipment the consumption may be reduced as much as 50 per cent. Injectors may also be advantageously employed where exhaust steam is available at pressure heads too low to admit of its use otherwise. By this means higher pressure steam may be diluted with steam which serves the purpose equally well of vapor carrier or heater, and which would otherwise be wasted as exhaust steam.

Vacuum distillation for lubricating oils is rapidly finding favor and is beginning to replace the "fire and steam" method. The advantages claimed for it have been higher quality, with particular reference to color, and increased separation of high boiling lubricating stock from asphaltic bottoms. The demonstration of the entire practicability of building vacuum stills in which abnormally low pressures may be maintained with comparative ease, in which the leaks are negligible and the work required by the vacuum pump comparatively small, must finally lead to the displacement of open steam in many distillation operations where the only reason for preference will be steam economy.

THE FOREGOING statements illustrate the dilemma of the refiner. The extent to which he can profitably use steam as a prime mover is intimately tied up with the use he can make of low pressure exhaust. Coincident, however, with his endeavors to use exhaust, he is continually and appreciably diminishing the demand. The question of the use of steam in the processing of petroleum boils down to the simple fact that its use is almost always uneconomical for any purpose other than heating, and then only when condensed and delivered as hot water. Otherwise the industry is rapidly becoming motorized and Dieselized.

From the operator's standpoint the main disadvantage of electric power is its greater liability to sudden and complete interruption, and the necessity in many cases of supplying spare steam-driven machines, backed up, of course, by more or less spare equipment for generation and delivery. Everything considered, however, costs are more often than not in favor of the use of electricity and the relegation of steam to the central power house, where in turn our old friend is apt to be rejected in favor of oil and the Diesel engine.

It is well to conclude with a word or two on meters. What with old custom and modern necessity, there are still so many avenues for the wasteful use of steam, that it is hard to conceive of an unprofitable meter investment, however extensive. It may well be carried down to the equipment of individual stills and operation by the "program" method. This consists in determining by test runs the optimum rate of temperature rise and the minimum rate of steam admission for a given stock, marking the charts of temperature recorder and steam meter with these rates by means of a template, and requiring the stillman to run so as to keep the pens of both instruments on the lines so drawn. The system of metering steam to each plant department, to each operation within the department; of budgeting its use on a test basis, and of frequent comparison between actual and allotted consumption, is sound practice and the best insurance that this major operating expense is reduced to and maintained at a minimum.

A Modern Power Plant in the Rayon Industry

Because of the large consumption of steam for process use and also for the generation of the power required by the textile machinery, the rayon manufacturer must maintain a large power plant. This photograph shows the boiler room of the new plant of the American Bemberg Corporation at Elizabethton, Tenn. It is equipped with three 400-hp. Springfield boilers, each provided with Sanford-Riley stokers. The power plant has two 750-kw. General Electric turbines direct connected to 440-volt a.c. generators.

An interesting feature of this power plant is that the boilers are set at the second floor level, providing a passageway directly beneath the ash hoppers. Motor trucks with special metal bodies serve conveniently for the removal of the ashes.

The coal handling system installed by the Alvey Ferguson Co. includes an inclined belt conveyor that carries the fuel to a parabolic steel bunker which extends the length of the boiler house and from which the coal is delivered to each boiler by means of a motor-driven weigh larry.

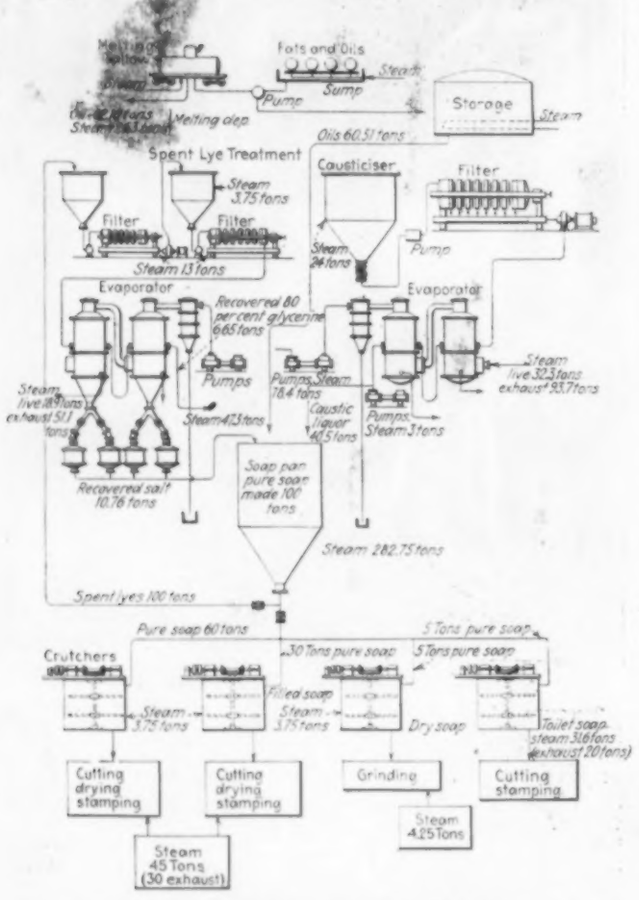
Process Steam in Soap Manufacture

EDITOR'S NOTE. *The following brief account of the application of process steam in the manufacture of soap is based primarily on data appearing in the recent British treatise "Modern Soap and Glycerine Manufacture," by E. T. Webb who is assistant to the works manager of Lever Bros. Ltd., at Port Sunlight. This book, published by Davis Bros. of London, was reviewed in Chem. & Met., August, 1927, page 500.*

A TON of soap requires about a ton of coal. In the pursuit of the elusive B.t.u. from the coal pile out through the works, the heavy consumers of heat beyond the power unit are the fat melters, soap-boiling pans, evaporators for caustic manufacture, evaporators for spent lye and glycerine recovery and the glycerine stills.

The manner of using steam for melting will vary in accordance with the method of shipping fats and oils. Tallow arrives in tank cars provided with steam coils by which the tallow is melted for pumping to storage tanks. Coils are also provided to maintain the tallow in the storage tanks in liquid condition. Fats received in drums are melted out by standing the opened packages on steam coils over vats or blowing a steam jet into the bung hole of the drums.

By far the greatest amount of steam consumed in a soap plant is used in the boiling kettles. This is not due to the cooking implied by the word "boiling," but rather by the number of "changes" or washes required for completing saponification and removing glycerine. Soap-boiling operations are often conducted intermittently for a period of six to nine days, interrupted by the need for settling. It is during the cooling period necessary to settling that much heat is lost. The actual saponification of fats by alkalis does not require great quantities of steam owing to the fact that temperature is maintained by the heat of reaction. In fact, during the saponification period steam supplied from perforated coils is used more for agitation than for supplying heat.



Flow Sheet of Soap Manufacture Showing Principal Applications of Process Steam

Modification of a flow and quantity sheet by E. T. Webb and published in "Modern Soap and Glycerine Manufacture," London (1927).

Up to this point the steam used has been at a pressure of about 80 lb. generally taken from the boilers at 160 lb. through a reducing valve. In the steps which follow, low-pressure steam is used mostly as exhaust steam from power producing units. The amount of power required in a soap factory for pumping, agitating, crutching and the various finishing operations is large enough to furnish considerable quantities of exhaust steam. The principal processes which use exhaust steam are evaporation and drying. Chronologically, drying comes after crutching. In the interest of economy, evaporators for the manufacture of caustic soda and for the recovery of spent lye are usually built as two effects. The use of more than two effects would call for more pressure than is usually available. Where the balance between power and steam is not well maintained, then there may be large enough quantities of exhaust to permit the operation of the exaporators as two single effects. In the latter case, the increased temperature drop available greatly increases the capacity of a given amount of heating surface, but at the expense of economy in the over-all operation of the factory.

Evaporation is the important heat-consuming operation in the production of materials used in soap making. A less important step which requires steam is that of filter pressing. Spent lyes, after chemical treatment, are filter pressed to remove the coagulated impurities as mud. Filter presses are also used in the manufacture of caustic soda. In both processes the filter cake must be blown with steam for the final removal of values.

AFTER the final change in the boiling pan followed by settling, the soap, still warm enough to be fluid, is run to the crutchers. The crutchers are jacketed tanks equipped with powerful agitators. The crutching process completes neutralization, incorporates filling, color, perfumes, etc. It is the final process in handling the soap as a liquid and little or no steam is used. When the process of crutching is finished, the soap is run into cooling frames. From the cooling frames the cooled and solidified soap is taken to cutters and from there to dryers.

Exhaust steam is used in the drying, the last operation requiring any appreciable quantity of heat.

From the tallow-melting coils the condensed steam is generally used for hot water in the building. The water from settling tanks may contain glycerine. Therefore, after dirt is removed from settlings they are pumped to the caustic departmnet, crude glycerine or soap-boiling department depending on plant conditions and upon glycerine content. Some plants exclusively use open steam for soap boiling. Hence there is no condensate. Other plants, at least in part, use closed coils from which the condensed steam is returned to the boiler. From the first effect of the evaporators and from the drying coils the hot drip is also returned to the boilers.

Modern Developments in the Steam Piping Field

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TODAY, we are confronted with the problem of successfully handling fluids and vapors at ever-increasing pressures and temperatures with the same degree of safety as we are wont to handle those of more moderate pressures and temperatures. Steam pressures from 400 to 500 lb. per sq.in. at a temperature of 750 deg. F. are today standard conditions with many manufacturing concerns and public utilities. Several large central stations and manufacturing concerns in this country and in Europe have even far exceeded these pressures. Two large central stations in this country have each one boiler and turbine in commercial operation using a steam pressure of 1,200 lb. per sq.in. and a temperature of 725 deg. F.

Design of High-Pressure Plants—Flow Diagram—The designs of high-pressure plants are undertaken in much the same manner as those for moderate pressure plants. They have for their foundation single-line flow diagrams which show the completed piping systems in a simplified form.

In order to develop such a diagram, a decision has to be reached as to the number and capacity of the various units and auxiliaries comprising the plant. This is based on the proposed plant capacity, taking into consideration the present demand as well as the possible and expected growth over a period of years, balancing operating costs against fixed charges until the most economical condition is reached. In this manner, the ultimate plant is designed, which when completed presents an orderly growth of the initial plant.

The diagram is then developed, arranging each individual piece of equipment in its proper sequence with respect to flow and as far as possible, in its relative position, with respect to elevation and plan. This facilitates visualizing the intended layout and also assists in the preliminary calculation of head and friction losses. The piping from the source or sources of supply to the respective headers and from the headers to the various points of distribution is then indicated by single lines of varying types, the better to trace each kind of service through its cycle of operation. Arrows are then placed parallel to the lines to indicate the direction of flow.

The necessary valves are then incorporated in the diagram. Each type of valve is indicated in some definite manner as an aid to the study of operation.

The final step in completing the diagram consists in selecting the pipe line sizes. These are determined approximately by judgment based on actual experience, pressure losses being of primary importance rather than actual velocities. As each system is finally detailed, a complete and careful check of the pipe sizes is made to insure proper operation of the system. Figs. 1 and 2 show typical flow diagrams as developed for a modern high-pressure central station.

Standards For Fittings and Pipe Flanges—One of the first difficulties encountered in detailing a plan to carry these higher pressures was the lack of standards for fittings and pipe flanges. As necessity is the mother of invention, various designs of high-pressure fittings and pipe flanges for high-temperature service were developed and placed in service, in an endeavor to obtain results which would be satisfactory in service.

This led to a rather chaotic condition as very expensive patterns and dies had to be made whose probable life was naturally very short, resulting in excessive costs for steel castings and steel forgings. The expected increase in station economy which would result from the use of higher pressures and temperatures was sufficient to justify this cost and consequently overcame the resistance to the advance toward the higher pressure field.

For the purpose of stabilizing the industry, in this respect, the American Engineering Standards Committee, in the early part of 1920, authorized the organization of a committee on standardization of pipe flanges and fittings for the purpose of unifying the various standards then in force in this country. Other societies were designated to sponsor the movement, representing contractors, manufacturers, engineers and consumers. As a result we are today much nearer the goal in that we have a tentative American Standard covering steel pipe flanges and flanged fittings for maximum working steam pressures of 250, 400, 600, 900 and 1,350 lb. per sq.in. at a temperature of 750 deg. F., which has been approved by the American Engineering Standards Committee. The time is not far distant when we will have a standard with 1,350 lb. per sq.in. pressure and 750 deg. F. as its upper limits. These standards may be used with safety for higher pressures, where the temperatures are reduced below 750 deg. F.

Materials—The pipe used for high-pressure work, for pressures up to 400 lb. per sq.in., has been lap welded, steel pipe with extra thick walls. For the higher steam pressures, however, seamless steel tubing has been generally used.

As temperatures were increased, in the early installations, it was found that cast iron could not be used for castings that were exposed to a temperature over 500 deg. F. as they were found to warp and deteriorate in strength in a comparatively short time. With steel the limits were higher.

Many tests have been made in the last few years to determine the variations in strength of metals with increase in temperature and these all indicate a quite distinct falling off in both the elastic limit and ultimate

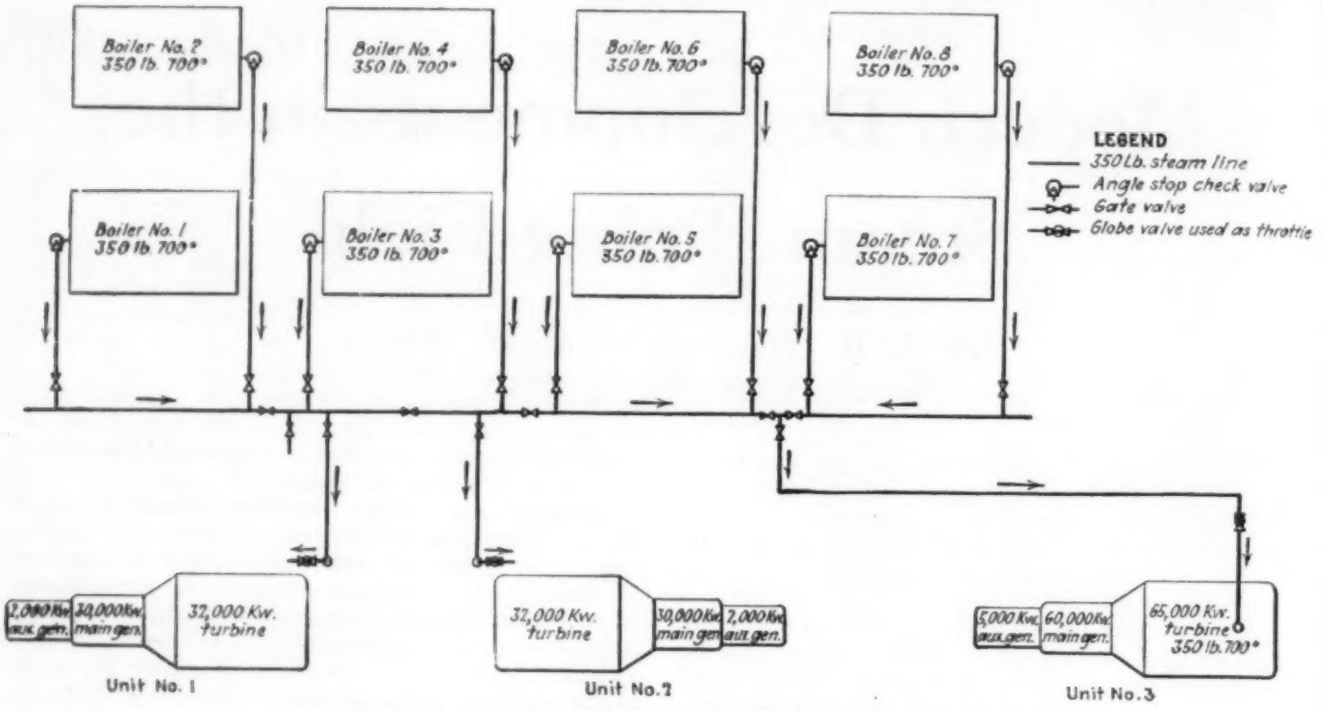

Fig. 1—Diagram of Modern High Pressure Piping System for Live Steam

strength if temperatures of 800 deg. F. are reached of exceeded.

Much research work has yet to be done before this weakness is overcome in order that we may go still higher with steam pressures and temperatures, to receive the benefits which they are capable of giving.

The making of sound steel castings to successfully withstand these higher pressures and temperatures is extremely difficult and subject to further study and improvement. One may say that all that is required is additional metal, in the various sections, to compensate for the increase in stresses. This is true to a certain extent. Steel castings have always been designed for a low fiber stress to compensate for internal defects. If this practice is to be extended to the higher pressure and temperature field, it will result in castings of enormous weight. With the knowledge and facilities that we have at hand today, it is possible, however, to make steel castings commercially that are homogeneous throughout, free from internal strains and defects and yet are not overburdened with excess metal. One of the most recent developments to this end is the use of the X-ray for the examination of steel castings. This has now reached a point where it is possible to successfully study the structure of steel at least 3 in. thick.

It is very essential, in high-pressure and high-temperature work, that steel castings as produced by manufacturers will successfully stand the severe service imposed upon them. A casting will oftentimes pass the specified hydrostatic test but when subjected to an X-ray examination, will be found to be in such condition that its life in service would be problematical.

The great value of examining steel castings by the X-ray lies in the absolute check of the foundry practice used and if defects are exposed, the cause is determined at once. In this way the foundry practice can be corrected and castings produced which will be more nearly perfect and at less cost than they are being made at the present time.

The difficulties attendant to the successful production of steel castings for high pressure and temperature service led to the fabricating of small steel fittings, valve bodies and bonnets by the drop-forge method. Forgings, by their process of manufacture, are superior to castings, as they are put through a heat-treating and hammering process which produces a metal of very close grain structure, eliminating, to a very great extent, the uncertain conditions inherent in steel castings. The use of steel forgings for high pressure and temperature service has proved very satisfactory.

Various metals have been used for trimming valves. The metal most desired is one which will withstand the severe cutting action of liquids and vapors at high pressures and high temperatures. Monel metal has been used to a great extent and has proved very satisfactory in service. Monel metal is nearly as strong as steel, is noncorroded, and is easily machined, taking a very high polish which makes it an acceptable substitute for steel. The development of noncorrodable steels provides another material which has been extensively used for valve trim. They compare favorably with Monel metal in regard to strength, toughness and hardness, and their use in high temperature service has been successful.

Flanged Joints—While the design of fittings and flanges has been going through its various stages of development, the joints retaining the higher pressures also have been subjected to serious thought. The ordinary threaded pipe flange joint has been found to be unsatisfactory for carrying high-temperature steam and water at pressures in excess of 250 lb. per sq.in. through lines whose diameter is $2\frac{1}{2}$ in. and over.

The Van Stone type of flanged joint overcomes this difficulty. It is formed by belling the pipe to follow the contour of the bore of the flange. When the flanges are bolted together, the joint is made between the belled faces of the pipes. Tightness may be insured by either a gasket, metallic or fibrous, or by seal welding.

With gasket joints it is very important that the faces be maintained parallel to each other, during service, to maintain a uniform distribution of gasket pressure

throughout. The unequal strains imposed on joints from the lineal expansion of the lines causes an uneven distribution of gasket pressure, resulting in failure. Gaskets have the characteristic of compressing during service which requires following up of the bolting with danger of stretching the bolts.

To improve gasketed joint construction many designs have been developed in which the gaskets are retained from blowing out under the pressure to which they are subjected. Among these may be mentioned tongue and grooved joints, step joints, recessed joints, and retaining ring joints. A metal to metal joint, seal-welded for tightness, has also been developed. This joint consists of a narrow circular bead, properly beveled and chamfered for welding, raised from the flange proper sufficiently far to allow access for welding. In the case of a fitting, this welding bead is machined integral with the flange while for a pipe flange the pipe itself is machined to form the bead after the pipe has been rolled over the face of the flange by the Van Stone method.

However, the piping standards previously mentioned require slight alteration where the welded bead construction is used, and in some instances it is necessary to increase the face to face dimension of fittings in order to permit flange bolts to be completely withdrawn.

Valve bonnets must be easily removable from the bodies which necessitates a gasket joint. As these joints are by nature very rigid they can be successfully sealed by totally retaining the gasket.

For pipes less than 2 in. in diameter, the ordinary screwed type of flange has been found satisfactory. The flange, of course, is necessarily made thicker as the pressure is increased. The raised face for supporting the gasket, may be extended sufficiently far from the flange proper to allow placing a gasket retaining ring around the outside of the raised faces, located inside of the bolts and between the flanges.

Bolting—The bolting has also been affected by the change in conditions and we now find that the ordinary commercial steel bolt and nut which have been satisfactory for moderate temperatures have been replaced by stud bolts of high-grade steel, each stud having a hexagonal nut at each end.

The bolting material which would be most desirable for high temperature service would be one which could stand a high stress while exposed to this high temperature without so-called crystallization. It is generally accepted now that studs made of a medium alloy steel and nuts of a mild carbon steel are satisfactory for this service. There is some question whether nuts should be cold-punched and casehardened or hot-forged and oil-treated to a Brinnel hardness slightly in excess of that of the stud. Up to the present time, nut failures have been very few. The majority of these have been caused by the sticking of the nut to the stud, consequently we are led to believe that nuts made by either process are satisfactory for the higher temperatures, cost alone being the deciding factor.

When studs first replaced the ordinary bolts they were made from rolled stock having a threaded portion at each end only sufficiently long to properly receive a nut, leaving a section between the threads, the diameter of which was greater than the diameter at the root of the thread. The stress distribution in a stud made in this manner is very uneven. The section of largest area, which is the unthreaded portion between the nuts, is stressed the least. The maximum stress occurs in the area at the root of the last thread, adjacent to the unthreaded portion. This is caused by the rapid change of section at that point producing a high concentration of stress. This uneven distribution of stress causes uneven elongation of the stud. With the high concentration of stress at the junction of the threaded and unthreaded portions, the maximum deformation will occur at this point, making this type of stud objectionable for high pressure and high temperature service.

Two types of studs have been designed to overcome this objection. The first type is threaded at both ends, in the same manner as the earlier stud, but the unthreaded portion is reduced to a diameter equal to that of the root diameter of the threaded portion. The second type is threaded from end to end. Both types overcome the objections found in the earlier stud in that they eliminate the high concentration of stress by having a uniform diameter from end to end.

All studs and nuts up to and including 1 in. in diam-

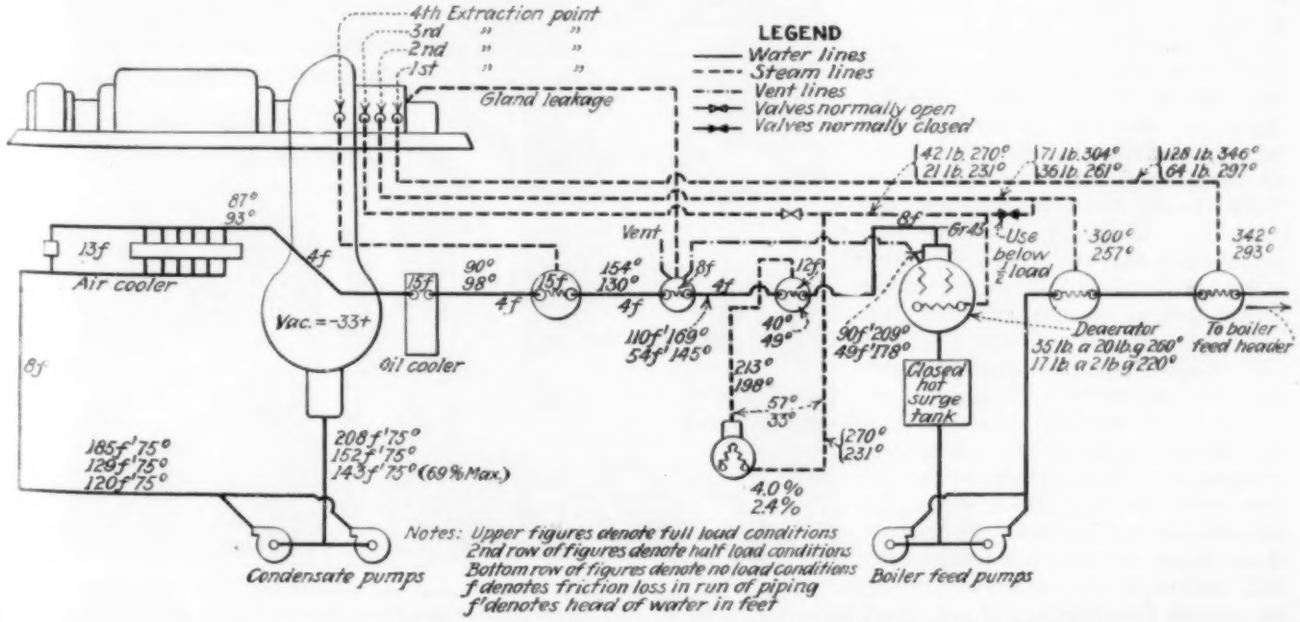

Fig. 2—Diagram of Modern High Pressure Piping System for Bled Steam and Condensate

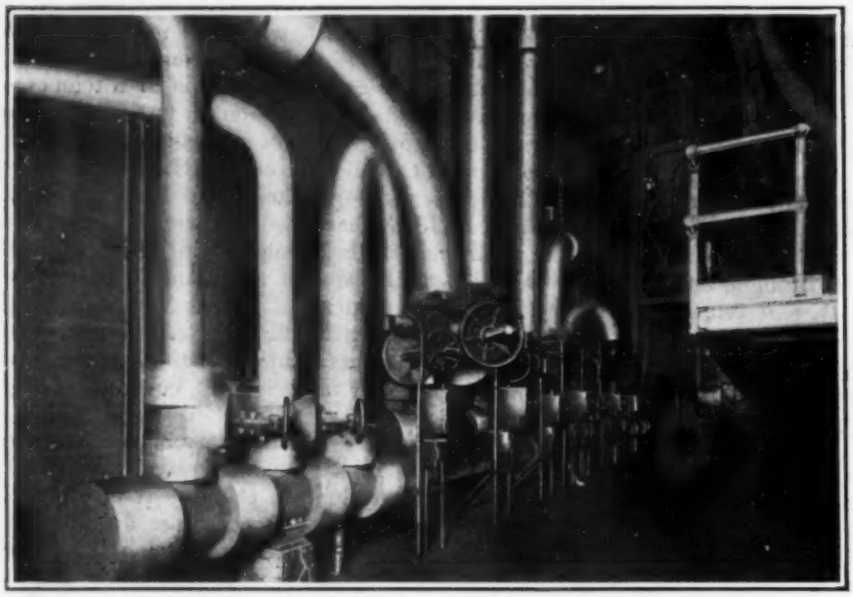

Fig. 3—Modern High Pressure Steam Piping Showing Motor Operated Valves

eter should have the standard form and number of threads per inch. To avoid coarse threads, it has become general practice to thread those larger than 1 in. in diameter with special threads of the standard form whose pitch is one-eighth of an inch (8 threads per inch).

Valves—Manufacturers in general have kept up with the pace and have produced reliable equipment suitable for steam up to 900 lb. per sq.in. pressure and a temperature of 750 deg. F. A few manufacturers are in a position to supply valves for still higher steam pressures, but as the demand for such valves, especially the larger sizes has been very small, there has been no tendency on the part of the manufacturers to place them on a production basis and consequently they are more or less special.

High-pressure valves for high temperature service are very similar to the ordinary low-pressure valves, the main difference being in the physical proportions. The unbalanced pressure on the seat rings, however, is much higher. This is generally overcome in the design of gate valves by introducing reduction gears between the valve stem and handwheel. Motor operation and bypasses become increasingly necessary with the higher pressures. Another factor that must not be overlooked in the design of these valves, is the choice of metals for seat and disk rings. These should differ in hardness and grain size, sufficiently to prevent seizing. Forged-steel valves are obtainable in the smaller sizes and are preferable to cast steel, as the uncertainty of steel castings is eliminated.

Welding—Another important development in the piping field, which is receiving more attention every day, is the use of gas or electric welded construction to replace screwed or flanged pipe joints and fittings. Welded pipe construction has found its greatest use in the lower pressure and temperature field and in the construction of long gas and oil lines.

In the gas and oil field the temperature conditions are not severe, being, to a large extent, due only to climatic changes. The pressure conditions, however, compare favorably with our modern steam and water installations in that new systems are continually being designed and placed in operation with ever-increasing pressures. The results have been uniformly satisfactory and have encouraged the extension of welding to the steam and water field.

Welded construction lends itself particularly well to the fabrication of special angle bends and special shape fittings, eliminating expensive patterns as well as the inherent difficulties previously mentioned as pertaining to the manufacture of steel castings.

In the application of welded construction to process piping, too much stress cannot be placed upon the importance of the careful selection of the welders, upon the strict adherence to the proper technique, and upon the care in testing the systems after completion. It is important that all welders be carefully tested to demonstrate their ability before being entrusted with important work. Periodically, the joints made by each welder should be carefully inspected, and in some cases, small sections removed from the joints and tested for strength.

Conclusions—The advance of the engineering world into the realm of high pressures and temperatures is being successfully accomplished and the benefits expected are being realized. In the beginning certain phases of the work were not entirely satisfactory, due mainly to lack of knowledge, but as time passed, experience was gained which enabled these minor difficulties to be overcome. The only barrier remaining today hindering further progress towards the still higher pressure and temperature field, is developing metals having the necessary characteristics to withstand these severe conditions.

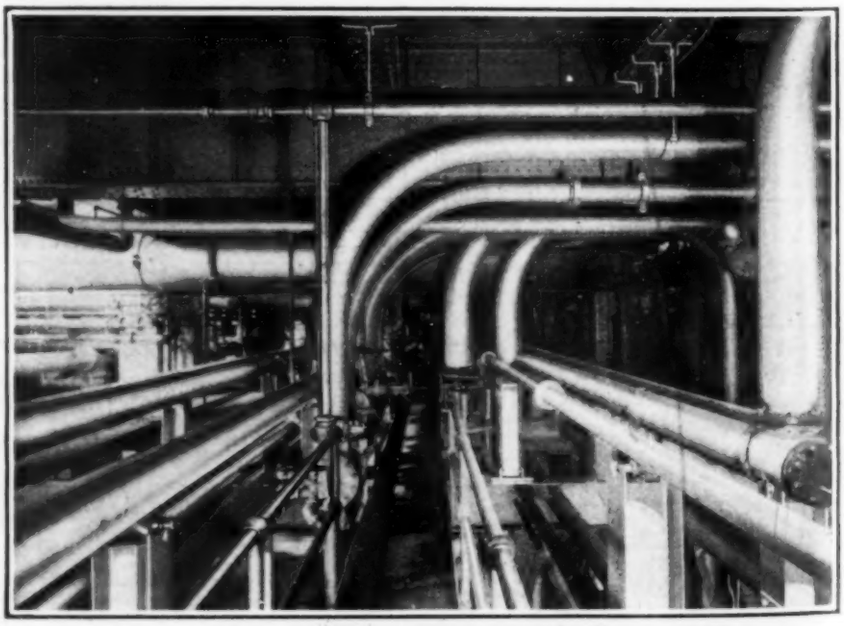

Fig. 4—High Pressure Steam Piping and Operating Gallery Above Boilers in a Modern Power Plant

Balancing Process Steam and Power in a Coated-Fabric Plant

By Lloyd C. Cooley
Chemical Engineer, New York, N. Y.

A MANUFACTURER of pyroxylin and rubber-coated fabrics has met the problem of mounting steam and power costs by the use of original methods in the automatic balancing of these two important steam requirements. In the account which follows, the story of the production and use of steam for process and power would be a bare assembly of flow diagrams and numerical data except for the unique arrangement developed and applied to the control of steam and power generation, accompanied by the accurate division between purchased power and that generated on the premises.

These results are accomplished in the plant of the Duratex Corporation in Newark, N. J., by an unusual arrangement of Smoot regulators devised by the plant engineer, E. H. Ward, in collaboration with the Smoot Engineering Company. The usual method of controlling these regulators depends on a separate source of loading pressure supplied through a master regulator which is controlled by boiler pressure. The loading pressure to each regulator unit is individually adjustable for combustion control. At the Duratex plant the loading pressure is derived from one of the governed units, namely, from the discharge duct of the forced-draft fan. The application of the process steam and of the regulators governing its production will be more easily understood from a summary of the manufacturing operations and of the steam-consuming equipment.

The principal products made by the Duratex Corporation are coated fabrics for the automobile industry and the upholstery trade. Each has a textile base which is dyed or impregnated prior to coating. One class of goods is coated with a pyroxylin compound, another with rubber, and a third, by a special process becomes the base for a natural hair carpet. (For a detailed description of process operations at this plant see *Chem. & Met.*, vol. 28, No. 23, June 11, 1923, pages 1017-1022.)

For this work, in general, the steam-consuming equipment is not especially intricate from a mechanical standpoint, consisting principally of dye machines, jig dyers, drying rolls or "cans," calender rolls, heavy-duty mills, Banbury internal rubber mixers and spreading and coating machines. In the use of steam, the machinery is divided into two groups, one requiring a pressure of about 75 to 110 lb., the other using steam at 5 lb.

The higher pressure is used where temperatures over 200 deg. F. are required, such as in the rubber-curing ovens and the calender rolls. The low-pressure steam is used in the dye tubs although these were designed originally to use higher pressure steam. Against the advice of dyers and dye-machine makers, low-pressure steam was successfully substituted, the equipment being provided, of course, with larger heating surfaces.

All of the dryers, drying cans and the hot-water supply for the plant are heated with exhaust steam. A constant supply of hot water is so arranged in an overhead tank that the time of filling and of heating the dye machines is greatly reduced.

The power load is always somewhat larger than the process steam load being in the neighborhood of 720 kw. while the steam load requires exhaust steam corresponding to an electric load of 200-500 kw. The company estimates that if electric power cost 0.25 cent per kw.-hr. to generate in the plant itself, having no condenser and exhausting steam to atmosphere such procedure would be uneconomical without some compensating factor, since current can be purchased from the Public Service Co. of New Jersey for an average cost of about 0.18 cent per kw.-hr. However, by operating turbines at 5 lb. back pressure and using the exhaust for processes, the power cost is reduced to about 0.05 cent per kw.-hr. The whole cost consists of heat lost in the steam passing through the turbine and the overhead charge for the turbo-generator unit.

STEAM is generated in two plants, a new and old boiler house. The old house has two Erie return tubular boilers of approximately 200 b.hp. each operated at about 80 lb. pressure with damper regulation. Before the new power house was built, the consulting engineer made studies of the cost of a stack having sufficient draft capacity to take care of two boilers without economizers and draft fans, compared with the cost of a shorter stack with forced and induced draft fans and an economizer. (For detailed description of this unique power plant see *Power*, vol. 56, No. 10, Sept. 5, 1922.)

As a result of this study one boiler was installed equipped with an economizer and fan. The new boiler is a Babcock & Wilcox 330 b.hp. water-tube boiler operating at 190 lb. pressure and 100 deg. superheat. During the winter period this has operated at 300 per cent of rating consistently for more than five years. The original fans have been replaced with Buffalo Forge duplex conoidal fans. The capacity of the forced-draft fan is 30,000 cu.ft. per min., that of the induced draft fan 50,000 cu.ft. per min., both at 5 in. water pressure. The use of constant-speed squirrel-cage motors to drive the two fans made necessary the control of the quantity of air by volumetric dampers. The characteristics of the fans are such that their efficiency is not impaired by the dampers.

The volumetric damper in the discharge duct of the forced-draft fan is controlled by a Smoot regulator, which in its simplest elements is a balanced lever with diaphragms at each end. The diaphragm at one end is under boiler pressure, while the other is subjected to pressure from the air duct of the forced-draft fan. The air duct pressure is the master pressure used for con-

trol of all the Smoot regulators. This is the unique feature of the control system emphasized at the beginning of this article. The ratio between this duct pressure and the steam pressure may be varied by adjustment of the fulcrum under the balanced lever. The induced draft fan works in conjunction with the forced-draft fan because its characteristics are similar and because its damper is connected through an adjustable mechanical connection to the Smoot regulator lever controlling the forced-draft fan. Thus any change in the forced-draft fan automatically makes a compensating change in the capacity of the induced-draft fan. In this way a constant pressure is maintained over the fire.

The fuel is No. 3 buckwheat anthracite coal burned on a Coxe chain grate stoker driven by a small steam engine. The steam engine throttle valve is controlled by another Smoot regulator, the balance lever of which is operated by the master loading pressure on one end and on the other, the centrifugal speed governor is belted to the stoker countershaft. The master loading pressure as applied to this regulator may be reduced through a bleeder valve the setting of which controls the ratio of air to fuel supply. In other words, the ratio between air supply and fuel supply can be altered, yet when once set the ratio is maintained constantly by the regulator

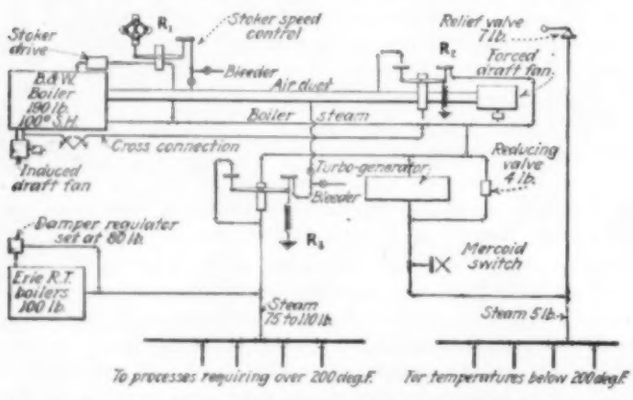

Fig. 1—How the Steam-Power Balance Is Controlled in a Coated-Fabric Plant

Regulators R_1, R_2 and R_3 control respectively the stoker speed, the volume of air delivered by each fan and the pressure in the 75-100-lb. steam line.

being under a master pressure. For example, when due to increased steam demand either from the turbine or from the high-pressure process line, there occurs a slight drop in boiler pressure, the forced-draft fan or master regulator is unbalanced, causing it to open the dampers on the forced- and induced-draft fans and to increase the volume of air sufficiently to accelerate combustion. The change in volume of air blown to the furnace increases slightly the air pressure in the duct which in turn unbalances the regulator governing the stoker engine so that more coal is fed. The ratio between coal and air, however, remains unchanged. The increased draft and fuel build up the boiler pressure which operates the first regulator in the reverse direction sufficiently to retard the increase in draft and it likewise operates the second regulator to retard the increase in fuel. Thus a new balance is obtained at a higher output of steam.

Requirements for steam at high pressure, namely, 75 to 110 lb., are met by taking steam from the B. & W. boiler through a reducing valve controlled by a third Smoot regulator. Like the two regulators previously described, this third one has a balance lever loaded by the master pressure of the air duct on one diaphragm but the other diaphragm is connected to the 75-110-lb. steam line. By the use of this regulator a balance is maintained between the output of the new and old boilers. The B. & W. boiler runs steadily at a high rating and any excess is handled by the regulator swinging the old boilers on to the line in the following manner: When the steam demand in the B. & W. has reached its capacity the fan duct pressure will be at its maximum. The result would so increase the loading pressure of the Smoot regulator on the reducing valve that a balance would only be reached by the continuation of a lower pressure than usual in the 75-110 lb. line. This inverse effect is made possible by the arrangement of the regulator. A higher loading pressure, like hanging on a heavier weight, is balanced by a lower steam pressure which is contrary to the method of operation of the first two Smoots described. (See Fig. 1.) The continuation of lowering in pressure mentioned above is effected by the Smoot regulator R_3 in cutting off the flow from the 190-lb. line to the 75-110-lb. line, thereby relieving the B. & W. boiler. The lowering of the pressure in the 75-110-lb. line below 80-lb. causes the damper regulator to open on the Erie boilers which increases their output of steam to handle the increased demand. As soon as the demand on the 75-110-lb. line is removed the pressure rises toward the normal and the damper regulator reduces the output from the old boilers.

Water for the boilers is provided by the condensed steam. Condensate from high pressure sources is run to a flash tank from which the vapor flows to the low-pressure main. The hot water from the flash tank is trapped through the vacuum return main into which all of the low-pressure apparatus discharges. A Nash condensate pump separates air and vapor from the condensate in the vacuum return main, pumping the latter to a heater in each boiler house. The heater in the new boiler house is 10 ft. higher than that in the old one. A float valve on the heater in the old boiler house supplies water as needed under 10 ft. of head. The remaining water passes along to the new boiler. In case of there being insufficient water, make-up is tapped from the city supply.

ELECTRIC power is supplied by a Rateau type turbine-driven generator fed from the new boiler at 190 lb. pressure and 100 deg. superheat, exhausting at 5 lb. back pressure. The power supply is distributed to seven principal loads each of which is equipped with double-throw switches in the lines, in order to permit of throwing the loads on to either the central station or to the factory supply. The approximate loads are as follows:

No. 1	30 kw.	Power house fan
No. 2	40 kw.	Air compressors
No. 3	70 kw.	Churn room motor
No. 4	100 kw.	Banbury mixer motor
No. 5	130 kw.	50-in. warming rolls
No. 6	150 kw.	60-in. mixing rolls
No. 7	200 kw.	220-volt small motor load

The 30-kw. fan load and 70-kw. churn motor load are each connected through a General Electric double-throw electrically operated switch to either the Public Service supply or to the plant generator. The control circuit of the switch is connected to a pressure-actuated Mercoid switch with a pressure diaphragm connected to the low-pressure steam main. This combination of switches is the striking feature of the automatic control of outside power consumed. (For electric power diagram see Fig. 2.)

The electric connections are such that when the pressure in the low-pressure main is reduced, the Mercoid causes the G.E. switch to connect its load to the power house generator. If the pressure in the low-pressure main rises above a predetermined value, the Mercoid reverses this connection, throwing the load on the Public Service line.

The 30-kw. load switching is set to operate on a quarter-pound change in the steam main pressure while the 70-kw. is set for a half-pound change. Thus the 30-kw. load is automatically changed for the smallest variation in pressure and if this is insufficient, it is followed by the 70-kw. load.

Consider the following example: A daily schedule which might be called an operating steam budget is made up of the probable exhaust steam demand with the equivalent amount of electric power. The double-throw switches are arranged so as to make the generator supply the number of kw. equivalent to the desired steam schedule for the day. If the schedule calls for steam equivalent to 330 kw. some such combination as 130+150 kw. would be carried by the Duratex power plant; 40+100+200 kw. would be on the Public Service line while the 30- and 70-kw. loads are carried automatically on either one according to the regulation desired. Thus we may assume the generator is carrying 310 kw. (130+150+30) while the Public Service has 340+70.

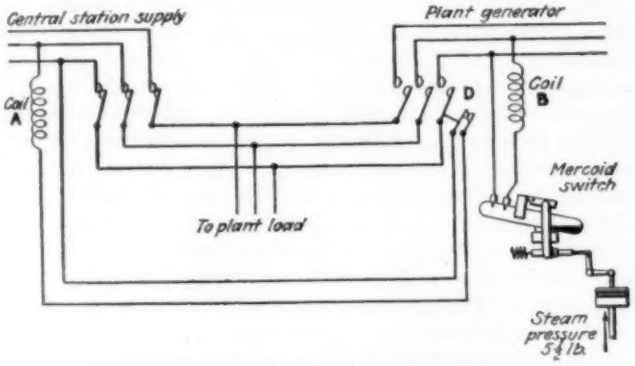

Fig. 2—How the Mercoid Switch Operates

The switches shown here represent the double-throw switch for either the 30- or 70-kw. loads. Coil A throws the switch in position to put the load on the central station supply. Coil B throws the switch in position to put the load on the plant generator. At the same time contact D is broken, cutting off the current from Coil A. In the diagram, a fall in steam pressure tilts the Mercoid switch so that the mercury flows away from the two contact points at the left end of the bulb. This action breaks the circuit so that no electric current flows in Coil B and the double throw switch will be opened by an arrangement not shown in this diagram. When the double throw switch is open, contact D is closed thereby causing electric current to flow in Coil A which closes the double throw switch in the position to throw the load on the central station supply.

This combination would probably furnish less exhaust steam than would be required. Therefore, the pressure in the exhaust main will fall until the Mercoid throws the 70-kw. load on the generator giving a load of 380 kw. With the increase in load on the generator, the turbine will increase the supply of exhaust steam, the pressure in the exhaust main will increase and swing beyond that corresponding to the 330 kw. originally desired, or until the Mercoid controlling 30 kw. will throw the load on the Public Service line. In this manner the Mercoid switches "hunt" for the proper balances. A recording pressure gage shows the amplitude of the swing to be limited to a small range.

It should be noted that the automatic devices have dampened the fluctuations in back-pressure to a lower average than when no automatics were used. Lower average back pressure carries with it a 2½ per cent lower steam rate per kw.-hr. Therefore, a greater number of kw.-hr. are obtained for a given amount of exhaust steam supplied.

If for any reason the steam demand is greater than would be supplied by the hand and automatic switches, the engineer in charge would note the need from his regular inspection of the pressure gage and would make the necessary alteration of hand-operated switches. From the new set of conditions thus established, the automatics will operate to keep the steam pressure regulated.

From the switch diagram it will be noted that in case of power house failure the load is automatically thrown on the Public Service supply and then the Mercoids are cut out. An arrangement of this sort goes a long way toward making the equipment fool-proof because no operator is required to throw the load on the Public Service when the turbo generator is shut down. Furthermore, there is a pressure-reducing valve situated on a bypass around the turbine. If the turbine is down or if for some other reason the exhaust main pressure falls below 4 lb., the pressure-reducing valve will open so that no process will be interrupted for lack of steam. On the other hand, if the pressure builds up too high, the excess is limited to 7 lb. by a relief valve.

The results of the combined control system are a gratifying justification of the investment in automatic regulation. Boiler steam costs have been reduced 20 per cent by the operation of the regulator. The interconnecting control between the two boiler plants reduced the operating time of the old fire-tube boilers. With the automatic switching arrangement, a precise balance is maintained between the demand for process steam and power. And, finally, the cost of power is reduced by the use of exhaust produced by the power unit.

For the privilege of studying the way this problem was solved in the plant of the Duratex Corporation, and for assistance in assembling the information here given, the writer is indebted to Ellery K. Files, works manager, E. H. Ward, plant engineer, and Curtis Myers, assistant plant engineer.

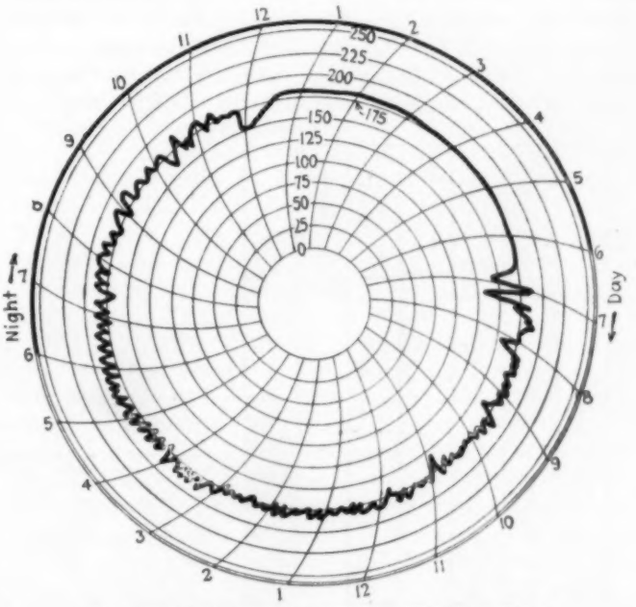

Fig. 3—Chart from a Recording Pressure Gage

This serves to illustrate the "hunting" action of the Mercoid switch. This particular chart was taken from a recording on the steam main which served the turbo-generator in the Duratex plant and which, of course, was indirectly affected by fluctuations in the exhaust steam main.

Byproduct Power from Steam Turbines

By C. B. CAMPBELL

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Westinghouse Electric & Manufacturing Company

IT HAS BEEN ESTIMATED that 23 per cent of all the coal mined in the United States is used by the industries. No estimate is available, however, of the portion of this fuel consumed by the industries in the actual generation of steam for use in manufacturing processes or for the development of power. The figure would probably be surprisingly large, especially when it is compared with the corresponding estimate of only 6½ per cent of the total coal mined being used by the central station power companies. With these figures in mind, some idea may be formed of the importance of the industrial steam plants in our economic structure, and of the necessity for solving their power and steam problems.

In the average industry, the cost of power is a small item in the total cost of the finished product. In spite of this, an increasing interest is being taken in the question of obtaining lower power charges. Higher fuel costs tend to increase the power item per unit of manufactured product unless improvements are made in the plant to offset this factor. For those industries purchasing power, this phase of the problem is being taken care of by the central station.

Another factor directing attention to the possibilities of reduction of power costs, is the fact that many industries are no longer able to add to manufacturing equipment and obtain proper return on the investment, unless they are able in some way to reduce costs to such a point that they can increase their markets against competition. Greater importance attaches to the smaller items of manufacturing cost, and of these, power and steam charges have, in many cases, been a profitable point of attack.

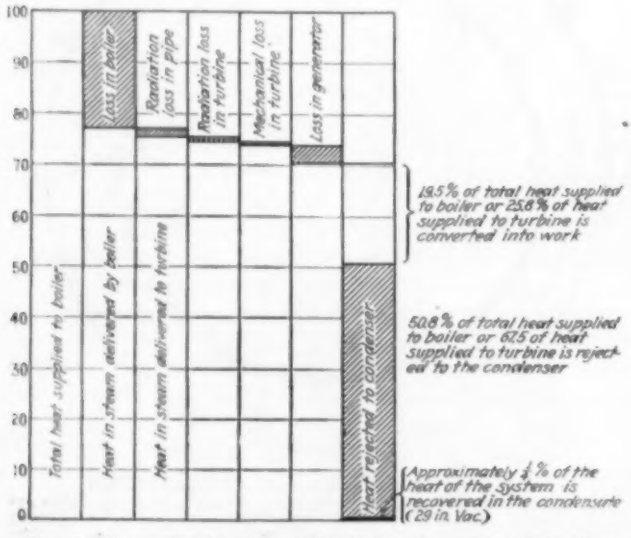

100
90
80
70
60
50
40
30
20
10
0
Total heat supplied to boiler
Heat in steam delivered by boiler
Heat in steam delivered to turbine
Loss in boiler
Radiation loss in pipe
Radiation loss in turbine
Mechanical loss in turbine
Loss in generator
Heat rejected to condenser
18.5% of total heat supplied to boiler or 25.8% of heat supplied to turbine is converted into work
50.8% of total heat supplied to boiler or 62.5 of heat supplied to turbine is rejected to the condenser
Approximately ½ % of the heat of the system is recovered in the condensate (29 in. Vac.)

Fig. 1—Approximate Heat Distribution for Plant Operating Straight Condensing

The manufacturing industries may be broadly divided into two classes: (1) those requiring power for the operation of manufacturing tools, but having no demand for steam in the process, and (2) those having both power and process steam demands to be served.

In the case of industries of the first class, it will generally be found advantageous to purchase power rather than generate it, unless local conditions dictate otherwise. There are cases where the location precludes purchase of power because of the cost of long transmission lines, together with the increased possibility of loss of power due to disturbances on this line. In other cases, the characteristics of the power demand are not suitable and purchased power becomes more expensive, as in the case of poor power factor, load factor, or, perhaps, odd or variable frequency, requiring frequency changing equipment. Where the power supply is an integral part of the manufacturing system, it is sometimes thought desirable to keep the generation of power under the control of the industry itself. One more exception occurs where power is purchased during the summer, and generated during the winter in connection with the supply of steam for building heating.

Conditions are much different in the case of plants of the second class designated above, commonly known as "process industries." These are built around a definite manufacturing process through which materials are converted from one state to another of greater marketability or value. Representative industries of this type are rubber, pulp and paper, oil, sugar, cement, soap, chemical, leather, explosives, etc. Power is required at various stages of the process for the operation of tools and special machinery, and steam is used for drying, cooking, evaporating, heating, distilling, etc. An idea of the magnitude of the power and steam problem involved in these plants is given by a recent survey indicating that process industries in this country consume nearly 100,000,000 tons of coal and 6,100,000,000 kw.-hr. of electrical energy in the course of a year.

Most of the larger process industries, at least, can develop their own power at a favorable unit cost by taking advantage of the possibility of co-ordinating the generation of steam for power and process. The more general realization of the economies obtainable in this way has brought about the development of equipment to serve the varied demands imposed by a great diversity of manufacturing processes.

In order to appreciate the unique features of a co-ordinated power and process installation, it will be necessary to keep in mind the conditions under which power

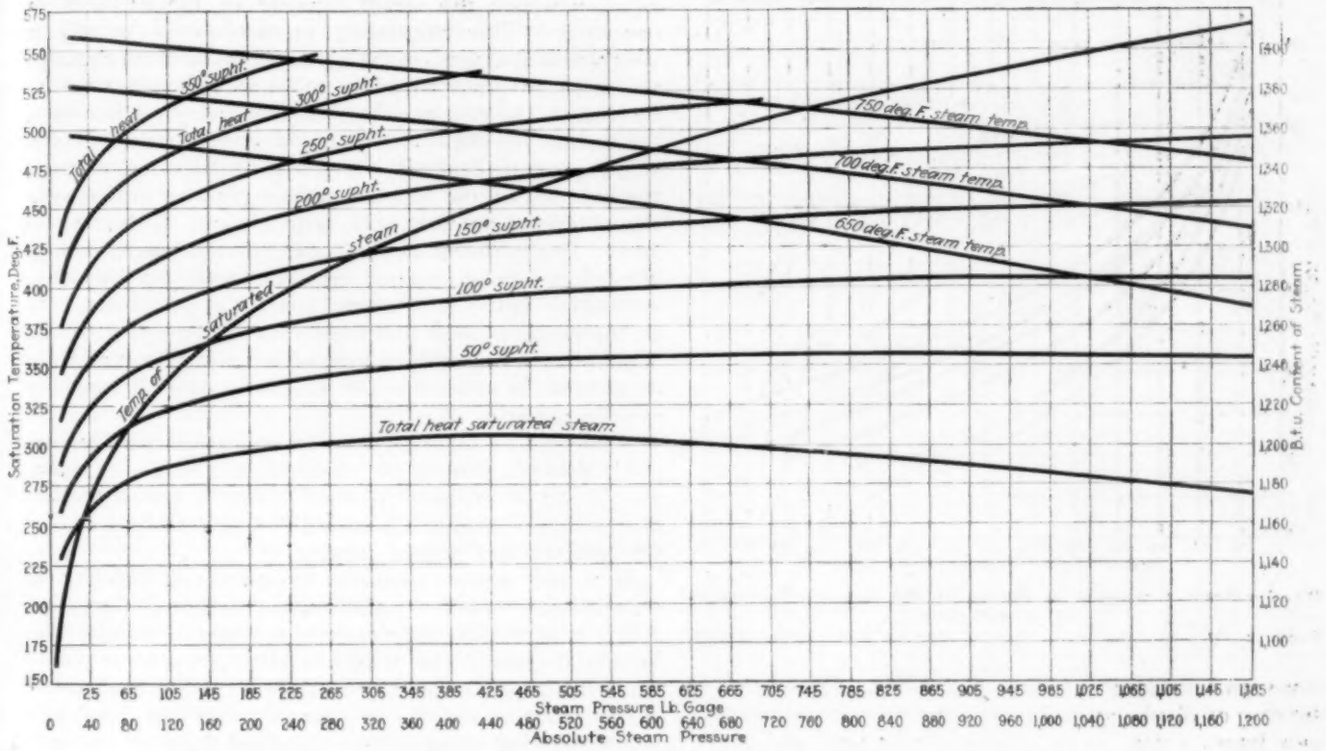


Fig. 2—Relation of Pressure and Saturation Temperature and of Pressure and Total Heat Content

is generated in the large central stations. The product of these stations is power, and every effort is made to generate this product as economically as possible, just as industries strive to reduce their manufacturing costs. Central stations are able to install large generating units and equipment of various kinds for effecting economies not justified in an industrial power plant, but even the best of such stations is extravagant in the use of heat and converts only a small part of the energy of the fuel consumed by the boilers into power. Fig. 1 indicates, roughly, the distribution of heat energy in the case of a plant operating with straight condensing steam turbines, without re-heating or stage bleeding for feed heat. The efficiency of the boiler plant complete is taken as 77 per cent. Radiation losses are 2 per cent in the piping system and 1 per cent in the turbine. The mechanical loss in the turbine is taken as 1 per cent and the generator loss 5 per cent. The heat equivalent of the power delivered will be of the order of 19.5 per cent of the total heat delivered to the boiler, or 25.8 per cent of the heat delivered to the turbine. The heat rejected to the condenser will be about 2½ times that actually converted into power. These figures are not to be taken as indicative of central station performance in more than a very general way, as recent installations incorporate re-heating and feed heating equipment with consequent important gains in station performance. In all cases, however, the heat rejected to the condenser, in the form of latent heat of the exhaust steam, is a large part of the initial heat supplied to the turbine. This loss is avoidable in process industries where the exhaust steam can be used in process manufacture, and consequently such industries can generate power in many cases at a very low cost.

In process industries steam must be generated: therefore, a boiler plant is necessary whether or not power is developed in the plant. In many such plants steam is generated in low pressure boilers for process use, and in others is throttled from a higher boiler pressure to the process lines, using pressure reducing and regulating valves, with power purchased, or developed in condensing turbines. A more economical scheme would provide for steam to be generated at a suitably high pressure and passed through turbines to reduce from boiler to process pressure, converting as much as possible of the heat energy made available by this expansion into power.

Careful consideration must be given to many factors in laying out a plant of this type. If a turbine is used in this manner, the heat content of each pound of steam exhausted by the turbine will be less than that of the steam supplied, therefore, for a given quantity of heat required in process, more steam will be required than if taken direct from the boiler, or through reducing valves. The loss in heat will, however, be small when considering the power developed. For each kilowatt-hour generated there must, of course, be a loss of heat in the steam of 3,415 B.t.u., the heat equivalent of a kilowatt-hour. There will, in addition, be a small loss, due to radiation and mechanical losses in the turbine, and copper, iron, windage and excitation losses in the generator. The various friction and eddy losses within the turbine merely reduce the amount of power than can be developed with a given steam flow between given pressure limits, with no loss of heat in the steam. All of the losses enumerated will not ordinarily bring the total heat loss in the turbine per net kilowatt-hour delivered above 3,800 B.t.u. The equivalent heat consumption, including the boiler losses, is about 5,000 B.t.u. Thus, power is developed with a heat consumption of less than 30 per cent of that in a central station, predicated, however, upon being able to use all of the exhaust steam in process, so that none of its heat energy need be charged to power cost.

To choose the proper type of installation for a given combination of plant operating conditions requires a

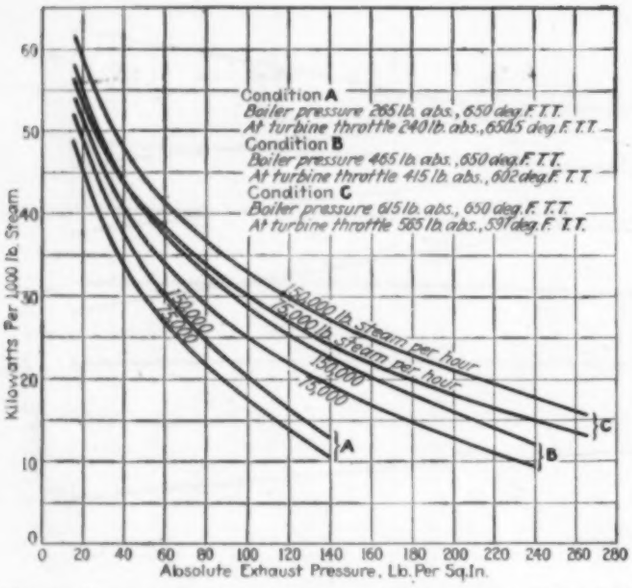

Condition A
Boiler pressure 265 lb. abs., 650 deg. F. T.T.
At turbine throttle 240 lb. abs., 650.5 deg. F. T.T.
Condition B
Boiler pressure 465 lb. abs., 650 deg. F. T.T.
At turbine throttle 415 lb. abs., 602 deg. F. T.T.
Condition C
Boiler pressure 615 lb. abs., 650 deg. F. T.T.
At turbine throttle 585 lb. abs., 591 deg. F. T.T.
150,000 lb. steam per hour
75,000
A
B
C
Kilowatts Per 1,000 lb. Steam
Absolute Exhaust Pressure, Lb. Per Sq. In.

Fig. 3—Steam Generated at Boilers at 650 Degrees Fahrenheit Total Temperature
Radiation loss of 2 per cent allowed between boiler and turbine.

thorough knowledge of these conditions. Obviously, in the case of plants operating six days a week and twenty-four hours a day, as is common in the pulp and paper industry, for instance, greater investment in fuel saving equipment is justified than in that larger number of industries operating only fifty or sixty hours a week. It is important to know relative values of power and process steam demands, whether or not they increase and decrease simultaneously, due to characteristics of the process, peak values, and normal values at which maximum efficiency is desired.

It is doubtful if any plant can be found having such relation of power and steam loads as to make possible a complete balance, with all power obtained as a by-product of the reduction of steam pressure to that required in manufacturing process. By providing reducing valves from the high pressure lines as a supplemental means of process steam supply, and operating electrically in parallel with other units capable of taking care of power demands in excess of that generated as byproduct, considerable flexibility is obtained.

The turbine involved in this case is a non-condensing unit exhausting at the desired process pressure, or, if steam is required at more than one pressure, it may be advantageous to use a non-condensing bleeder turbine.

By a non-condensing turbine is meant a machine exhausting at atmospheric or some higher pressure. It is obvious, however, that if the heat of exhaust steam can be used at a pressure below atmosphere, and a temperature below 212 deg. F., a machine of this type may be employed with a partial vacuum at the exhaust, thus, strictly speaking, not coming under the heading of non-condensing turbine, in the generally accepted meaning of the term. It will be understood, then, that machines for such partial vacuum heating service are included when we speak of non-condensing units, and an outstanding example of such an application will be given later.

Non-condensing turbines are frequently equipped with exhaust pressure regulators, by means of which the exhaust pressure is held practically constant regardless of variation of demand for process steam, so long as it is within the steam capacity of the turbines so operating. This regulating mechanism is usually a weighted diaphragm operating a relay that in turn causes the main governor to admit more or less steam to the turbine, as the case may be. At any moment, therefore, the turbine develops whatever power is possible with the existing steam demand. If the steam demand exceeds the capacity of the turbine, reducing valves will supply the difference automatically, with a slight drop in pressure. If the power demand exceeds that generated as byproduct, the difference must be made up by other generating units, presumably operating condensing. It is, therefore, evident that the power and steam demands should be studied with an idea of balancing them as fully as possible, in order that the maximum over-all economy may be obtained.

This type of machine may be equipped with thermostatic control, instead of pressure, if desired. In this way it can be made to produce power by passing whatever steam is required to maintain a practically constant temperature in a heating process.

It would appear desirable to operate electrically in parallel with a central station power distribution system, rather than to generate power in condensing units in the industrial plant. This would result in the excess power being developed in large and efficient stations, and would also provide an outlet for power in case that developed by the reducing valve turbines exceeded the plant demand. A load of this character will usually be quite irregular, with abrupt peak values. The power fed back into the distribution system will be of the same character and not always desirable from the power companies' standpoint. Such a condition may be sufficient to justify the installation of condensing turbines in the industrial plant. Steam accumulators in the process system may be provided to absorb short period peak demands, and thus, result in a

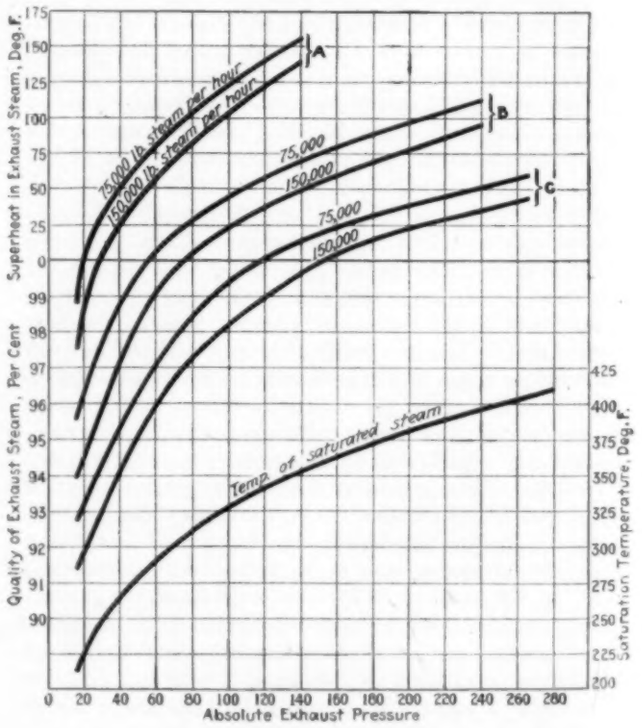


Fig. 4—Approximate Condition of Exhaust Steam
Steam generated at boilers at 650 degrees Fahrenheit, operating conditions same is in Fig. 3.

satisfactory connection with the central station. This is a proper problem for negotiation in each particular case.

Ordinarily, the heat required by process is known from past records, or can be closely estimated. In many cases it is unimportant, except in so far as the piping system is concerned, whether this heat is obtained from relatively high or low pressure steam. Fig. 2 shows the relation between steam pressure and saturation temperature, also between steam pressure and total heat content per pound of steam for various degrees of superheat. The former relation is better illustrated for ordinary process pressures by the lower curve on Figs. 4 and 6. Steam cannot usually be used for heating to a temperature greater than its saturation temperature, even though the steam be superheated, therefore, the temperature required in the process is an important factor in determining the exhaust steam pressure. For a given initial steam condition, the lower the exhaust pressure on the turbine, the greater the power produced, illustrated by Figs. 3 and 5. On the other hand, low pressure means large steam piping, with increased installation costs.

Fig. 2 shows that for a given quality, or superheat, the total heat content of steam does not change rapidly with pressure. This means that a comparatively small increase in quantity of steam is necessary, in order to obtain a given total heat quantity, in case the steam pressure is reduced, quality or superheat remaining constant. Figs. 3 and 5 indicate, on the other hand, that a reduction in exhaust pressure increases the power output of the generating unit very rapidly. In general, it would seem that as low a process pressure as is practicable from the manufacturing standpoint should be adopted, and piping be designed accordingly.

Knowing the exhaust pressure, the problem is then to choose high pressure steam conditions that will best balance the plant demands. This will involve a choice to make possible the generation of required power with required steam for process. Starting with 650 deg. F. and 750 deg. F. steam temperature at the boiler, respectively, Figs. 3 and 5 show about the maximum power that can be developed per 1,000 lb. of steam per hour for various throttle and exhaust pressures. These curves are made

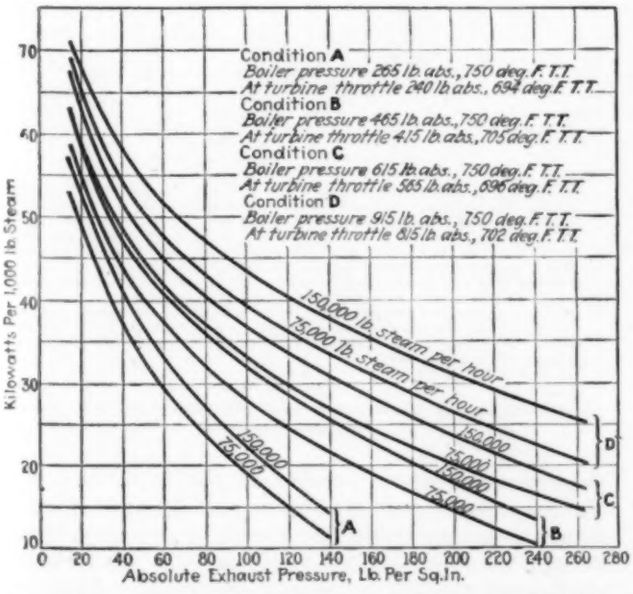

Condition A
Boiler pressure 265 lb. abs., 750 deg. F. T.T.
At turbine throttle 240 lb. abs., 694 deg. F. T.T.
Condition B
Boiler pressure 465 lb. abs., 750 deg. F. T.T.
At turbine throttle 415 lb. abs., 705 deg. F. T.T.
Condition C
Boiler pressure 615 lb. abs., 750 deg. F. T.T.
At turbine throttle 585 lb. abs., 696 deg. F. T.T.
Condition D
Boiler pressure 915 lb. abs., 750 deg. F. T.T.
At turbine throttle 815 lb. abs., 702 deg. F. T.T.
150,000 lb. steam per hour
75,000 lb. steam per hour
Kilowatts Per 1,000 lb. Steam
Absolute Exhaust Pressure, Lb. Per Sq.In.

Fig. 5—Steam Generated at Boilers at 750 Degrees Fahrenheit Total Temperature
Radiation loss of 2 per cent allowed between boiler and turbine.

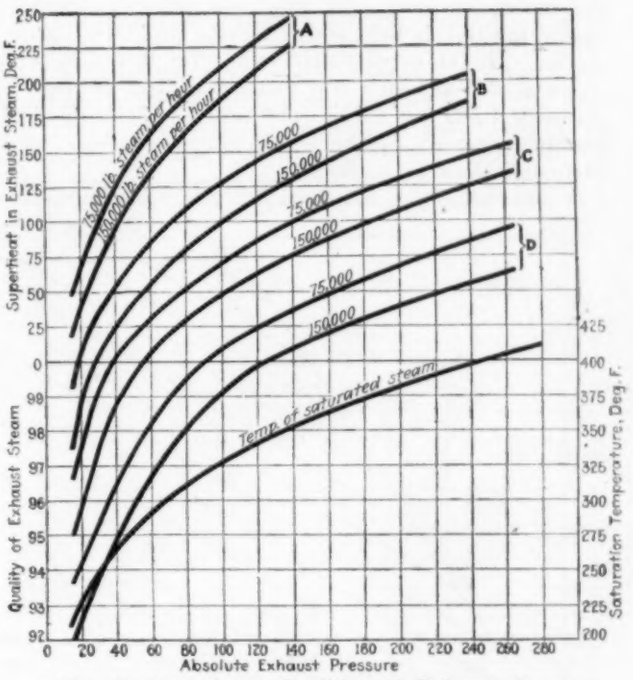

150,000 lb. steam per hour
75,000 lb. steam per hour
Temp. of saturated steam
Superheat in Exhaust Steam, Deg. F.
Quality of Exhaust Steam
Saturation Temperature, Deg. F.
Absolute Exhaust Pressure

Fig. 6—Approximate Condition of Exhaust Steam
Steam generated at boilers at 750 degrees Fahrenheit, operating conditions same as in Fig. 5.

up on the basis of the turbine being designed for best performance at each point illustrated, and cannot be used in estimating performance over any range of steam flows on a single machine. A radiation loss of 2 per cent has been allowed between boiler and turbine, and allowance made for a line pressure drop as noted.

Corresponding to the conditions of Figs. 3 and 5, Figs. 4 and 6 show the approximate state of the exhaust steam, from which the heat content per pound may be calculated and the quantity of steam required be determined. In some cases the problem is a bit more involved, in that, not only is the total heat quantity of the exhaust steam important, but the condition of this steam is a factor. For instance, when used in digesters in pulp and paper mills, it is common to find a decided prejudice against more than about 25 deg. F. superheat in the steam, because of difficulty in controlling the temperature of the cook. In such cases, curves as given in Figs. 4 and 6 are useful in permitting the ready choice of initial conditions that will give the power required with the quantity of exhaust steam demanded and of the desired quality, or superheat.

It is generally considered that a steam temperature of 750 deg. F. is about the maximum practicable at the present time, this limitation being established by the materials available for construction of equipment subjected to this temperature. Many central stations have been in operation for some time with 750 deg. F. steam temperature and some few industrial plants are operating under similar temperature conditions without difficulty.

Steam pressures up to 1,200 or 1,400 lb. are considered entirely practicable. A few central stations have equipment operating at this pressure, using 1,200 lb. turbine units for the development of power in reducing this pressure to that used in older machines in the plant. It is thought that process industries should lead in the installation of high pressure equipment, as the possible gain in over-all plant economy is much greater than in

the central stations. At least one process industry is pioneering in this field and is putting an 800-lb. plant in service. In this particular case, the turbines receive steam at 725 lb. gage and exhaust at 165 lb. gage, developing 4,740 kw. each. The process steam demand is greatly in excess of the equivalent power load, in the particular plant in question.

A non-condensing installation is relatively inexpensive.

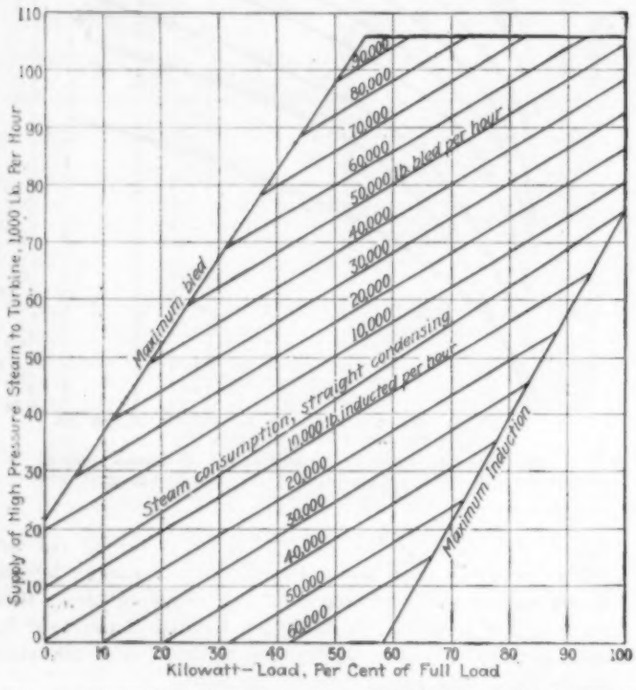


Fig. 7—Typical Performance of a Combination Bleeder-Mixed Pressure Turbine

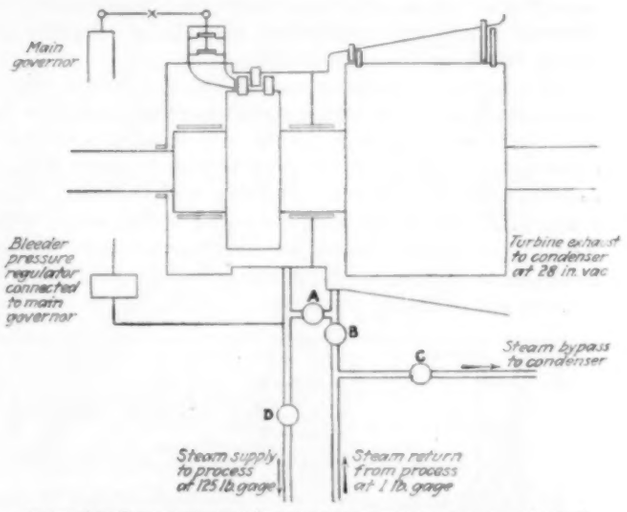
There is no condenser with its auxiliaries and tunnels for water supply, and the foundation is, therefore, greatly simplified and cheapened. The problem of obtaining suitable boiler feed may be serious, especially with high boiler pressures, unless a large part of the process steam is condensed in the heating system and returned uncontaminated.

In serving steam and power loads it is quite common to use bleeder type turbines, in which the non-condensing element with process steam pressure control is combined in a single unit with the condensing element. Only that power developed by the steam required for process can be considered byproduct. The additional steam needed to carry the power load gives up a large portion of its heat to the condenser water. The average range of operation expected of a machine of this type should be established in order that it may be designed to expand the steam as efficiently as possible, otherwise, the theoretical gain may be largely lost.

An automatic bleeder turbine includes a pressure regulating device at a suitable point in the machine, this mechanism being designed to throttle the steam flow to succeeding stages in so far as necessary to establish the desired pressure at the extraction point. At a given electrical load, an increase in steam bled calls for a corresponding increase in steam supply to the turbine in the ratio of the heat, per pound of steam, converted into work in the condensing element to the heat, per pound of steam, converted into work in the complete machine. Thus, actual values are dependent upon conditions of operation. Fig. 8 is merely intended to illustrate the flexibility of the automatic bleeder turbine. By "maximum bled" is meant operation with the bleeder valve closed and no steam except leakage flowing to the condenser.

Modifications of the standard bleeder turbine permit the automatic induction of steam in case there is an excess of low pressure steam available in the system at any time. The expansion of this excess steam in the condensing element results in a reduction in quantity of high pressure steam used for a given load. This type of turbine, known as a "bleeder-mixed-pressure" is useful when bleeding into a system supplied also by exhaust from non-condensing turbines, air compressors, steam hammers, etc. The valve gear is arranged to put the low pressure steam under control of the speed responsive governor. The effect of induction of low pressure steam on high pressure steam consumption is shown in the lower part of curve, Fig. 7.

Fig. 8 shows the general arrangement of the controls on a turbine recently installed, where combined steam and power loads are involved. Steam is supplied to the turbine at 250 lb. gage, 100 deg. F. superheat. Steam at 125 lb. gage is extracted at an intermediate point in the machine, this steam being used principally to drive centrifugal pumps. Part of this steam is used in evaporators. The pump drives operate non-condensing part of the exhaust being used in evaporators and an average of about 75 per cent of it being available for re-induction into the turbine to produce power in its


Main governor
Bleeder pressure regulator connected to main governor
Turbine exhaust to condenser at 28 in. vac
A
B
C
Steam bypass to condenser
D
Steam supply to process at 125 lb. gage
Steam return from process at 1 lb. gage

*Valves **A** and **B** are controlled by a low pressure steam governor. Valve **B** serves as a primary and valve **A** as a secondary valve in the low pressure steam chest. **B** is a combination constant pressure and governor valve which only opens under governor control for the admission of low pressure steam to the turbine when the line pressure is 1 lb. gage or more. **A** is a governor controlled bypass from the 125 lb. zone to the low pressure element and only opens when the electrical demand exceeds that available from the steam required and returned by the process.*
C is a constant pressure valve opening at about 3 lb. and by-passing steam from low pressure line to condenser, in this way conserving boiler feed water at such times as the electrical load is too light to require use of all the process steam available.
D is a check valve.

Fig. 8—Diagram Illustrating the Flexibility of the Automatic Bleeder Turbine

expansion to 28-in. vacuum at the exhaust. In case the electrical load does not permit use of all the return steam available, the excess is passed to the condenser and clean boiler feed water is conserved. If the electrical load is greater than that corresponding to the steam load, a bypass is opened by the low pressure

governor, putting steam from the 125 lb. line directly into the low pressure inlet, and thus, in effect, increasing the bleeder demand to such a point as to carry the power load. The main governor is made pressure responsive, admitting just sufficient steam to maintain the bleeder pressure irrespective of the demand, except that in case of complete loss of load it will shut off steam as the speed increases. This is a 1,000 kw. turbine, under average operating conditions developing about one-third of its load as byproduct power, and having great flexibility to cover a wide range of possible operating conditions.

It is also possible to bleed non-automatically for process steam. In such a turbine there is no restriction to the steam flow through the machine, therefore, steam can only be bled at a pressure equal or less than that corresponding to the actual flow through the succeeding elements. This type of turbine is not as common in industrial plants as the automatic bleeder as it lacks the flexibility of the latter. Fig. 9 illustartes this characteristic, it being evident that the machine has no bleeding capacity at light load. This figure illustrates the case of two stages of non-automatic bleeding, where, at heavy loads, the steam will be extracted from a point of lower pressure in the turbine, with consequent greater efficiency as a bleeder. A machine of this type has a limited application, demanding for best results that the power and steam loads be related and increase or decrease together.

An important application of the principle of non-automatic bleeding is illustrated in Fig. 10, showing the general arrangement adopted when generating power as a byproduct of the heating of feed water. This turbine

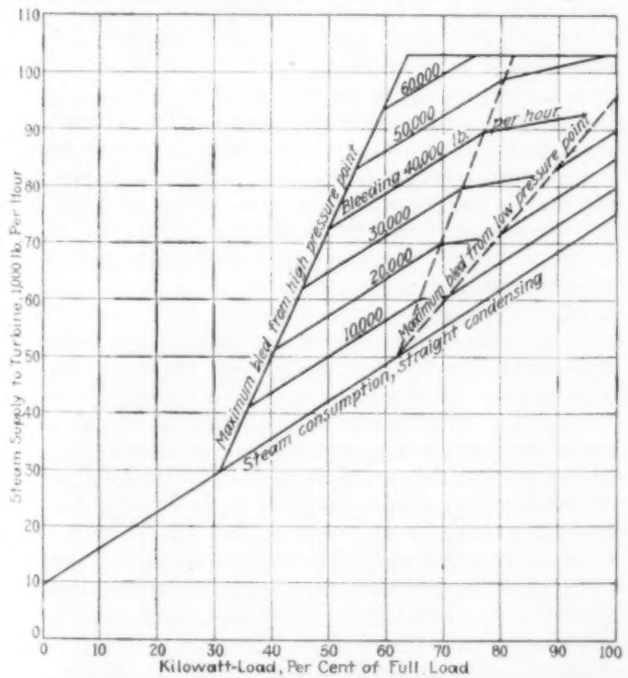
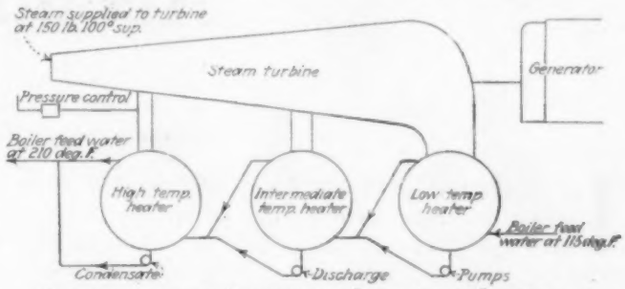


Fig. 9—Typical Performance of a Double Non-Automatic Bleeder Turbine

receives steam at 150 lb. pressure, 100 deg. F. superheat, exhausts approximately one-third of its steam at each of three points into heaters in which a large quantity of boiler feed water is heated successively from 115 to 210 deg. F. When delivering a total of 960,000 lb. of boiler feed per hour at 210 deg. F. the turbine develops about 4,600 kw. A regulator at the high pressure bleed point causes the governor to admit sufficient steam at all times to maintain atmospheric pressure at this point, regardless of fluctuations in rate of boiler feed flow, thus insuring uniform discharge temperature. This is the case previously referred to, of byproduct power being developed by a turbine operating partially condensing.

The determination of the cost of developing power in



General arrangement of installation in a "process industry" in which power is obtained as a byproduct of the heating of boiler feed water. The turbine is equipped with a pressure regulator maintaining atmospheric pressure at the high pressure bleed point, so that, regardless of quantity of feed water circulated, it will be heated to 210 deg. F. and load on turbine will change accordingly

Fig. 10—Diagram of Feed Heater Turbine Installation

connection with the supply of process steam demands, also, a complete analysis of the costs of the plant required for steam generation only. In a paper presented at the annual meeting of the A.S.M.E. in December, 1925, Mr. W. F. Ryan, power engineer of the Solvay Process Company, gave the results of a study he made of the cost of power developed by a plant operating with variable throttle pressures, 725 deg. F. throttle steam temperature and 165 lb. gage exhaust pressure. In his case, all of the steam exhausted was used in the manufacturing process. The cost of installing and operating a 200 lb. boiler plant to supply steam of a given heat content was deducted from the cost of a high pressure boiler plant with suitable non-condensing turbine, all designed to give process steam of the same heat content. The difference in cost of these plants was charged to power and worked out to be as follows:

Turbine Throttle Pressure	Load Factor	Total Power Cost—Cents per Kw.hr.
400	100	0.30
	50	0.45
	25	0.80
600	100	0.30
	50	0.50
	25	0.85
800	100	0.33
	50	0.56
	25	1.02
1,000	100	0.46
	50	0.70
	25	1.30

The effect of load factor is, of course, especially important in the case of high pressure plants, due to the increased investment charges. This penalizes those plants that do not operate on a practically continuous basis when it comes to pressures much above 600 lb.

The figures above, taken from Mr. Ryan's paper, are considered a fair index of the power cost that may reasonably be expected under the conditions stated, and, therefore, as an indication of the effect of higher steam pressures for other combinations of superheat and exhaust pressure as well. It should be understood that there is little information available on this problem of costs for process steam and power plants and that it is, therefore, not safe to generalize on the subject. Each case deserves separate analysis, because of the possibilities presented.

Application of Steam Accumulators

By Grover Keeth
Marathon Paper Mills Company, Rothschild, Wis.

IN LOOKING ABOUT for a solution of a pulp and paper mill heat balance, the writer decided to see what application could be made of an accumulator in working out this problem and is offering his ideas in this regard and also observations made at several mills, which are equipped with accumulators, as they may be of interest to others with the same problem.

The problem confronting the writer was that of a paper mill, operating on the sulphite process and having four digesters, one board machine, two fourdrinier machines and one Yankee machine. Steam is being supplied by two boiler rooms at 150 lb. pressure. Live steam is, of course, used in the digesters and low pressure steam for the paper machines, building heat, etc. Power is supplied by a non-condensing Corliss engine, a hydro-electric plant, a condensing turbine and a purchased power connection.

The low-pressure steam and power demands of the mill are fairly constant, while the live steam demand of the digesters varies in rate from 0 to 54,000 lb. per hour. The hydro-electric plant is of fairly low head, so that the output is materially affected by the season of the year, the maximum output being three times the minimum. A study of steam turbines operated at high initial pressures revealed the fact that considerable power could be generated by the use of a high pressure turbine operated either as a high back-pressure machine or a bleeder, when making use of the steam used by the digesters. However, it was also evident that when river conditions were good there would be no place to use the power generated by this high-pressure steam.

The variable steam demands of the digester department produced a very unsatisfactory operating condition in the boiler rooms and for the reason above mentioned, it was apparent that these variations would not be ironed out by going to a higher steam pressure and the decision was, therefore, made to investigate the steam accumulator. The writer visited installations which will be designated as "A," "B," "C" and "D." I quote herewith from my notes:

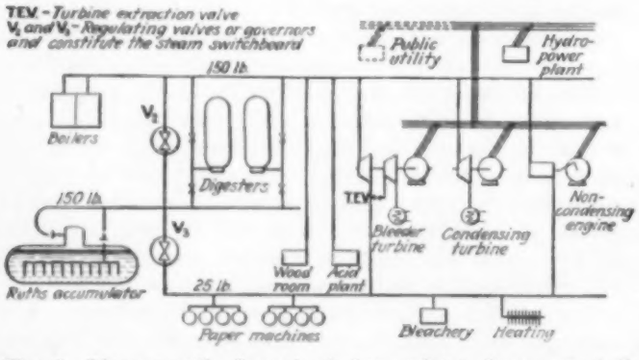


Fig. 1—Diagrammatic Layout of Accumulator Arrangement in the Typical Pulp and Paper Mill

Mill "A" has a boiler plant containing six boilers of about 500 hp. nominal rating. These boilers are equipped with Coxe stokers and burn a small size of anthracite coal. The working steam pressure is 125 lb. and there is some superheat. The steam is used for process purposes only, all power being obtained from a power company. The digesters are operated at 30 lb. pressure. The plant was put in operation about three years ago and the accumulator installed at the same time. These boilers are operated at a rate of about 175 per cent, which does not seem to vary more than seven or eight points either way throughout the week. The steam pressure line looks as though it had been drawn with a compass. The boiler room foreman informed me that no repairs had been made to any of the accumulator equipment since it had been installed.

At mill "B" they were also well pleased with their accumulator in spite of the fact that they were apparently not operating it to best advantage, due to a discrepancy in steam gages and because the firemen were endeavoring to maintain a constant accumulator pressure instead of a constant boiler load. They were just starting up two new digesters and had not gotten them properly tuned up. They were, however, operating one less boiler than they had previous to the installation of the accumulator.

Mill "C" was just as enthusiastic over their accumulator as were the two paper companies, and stated that they would not attempt to run their process without an accumulator. This mill generated its own power and but for the fact that there was no hydro or outside power, made the conditions somewhat similar to our own. One of their operations consists in concentration of syrup at 80 lb. steam pressure. Previous to the installation of the accumulator, this operation took four hours, but it is now done in three hours and the quality improved as well.

We quote herewith from a letter received from mill "D": "Relative to your letter of the 11th, with reference to steam accumulator, each installation has to be individually adapted to the mill where it is installed. If the steam accumulator people recommend installation in your case, we feel that you can rely on their judgment. Accumulator probably saves use five tons of coal per day. Other advantages are a steady pressure and better operation of all equipment using low pressure steam such as vacuum evaporators and paper machines."

In working on our heat balance, the writer discussed the situation with numerous builders of steam turbines for the purpose of finding out what could be accomplished

with turbines at various pressures, but concluded that his problem was one of correcting uneven combustion conditions rather than obtaining additional power with the same amount of coal, or making a reduction in the coal used for power generation, because of the hydro-electric plant situation. There is use for all of the exhaust steam produced and the electric power requirements are reasonably well taken care of.

Observations taken in our boiler room show that it is impossible to obtain good stoker operation with the great variation in live steam demands. The accumulator has been given consideration for the reason that it is the only method that the writer knows of that permits constant boiler operation.

Turbine men who read this article will, no doubt, claim that the steam which has passed through the accumulator into the low pressure system has not generated any power. I grant this contention, but hold that this is the price we will have to pay for getting a uniform boiler load, which we feel is far more desirable and will in the end produce cheaper steam than if it had been made use of to generate power on its way from the boiler room to the low pressure steam system. Further, this uniform boiler load results in an almost constant steam pressure which I feel will be of considerable advantage to our prime movers. A steady steam pressure should be particularly desirable for any mill driving their paper machine with a variable speed turbine. It was found in one case that previous to the installation of an accumulator the turbine driving the paper machine varied in speed as much as 4 per cent due to variations in steam pressure. After installing an accumulator this variation was less than 0.5 per cent.

In investigating the accumulator, the writer found that there is no theoretical method of calculating the size of an accumulator. In order to arrive at an accumulator size it is necessary that the manufacturer be given the best possible analysis of the customer's present conditions. From a study of this analysis and results obtained by previous installations, the accumulator manufacturer arrives at a size, which so far as I could find, comes reasonably close to the required conditions.

The accumulator is placed out-of-doors so that it is not necessary to charge any building space to it, and, as it is well lagged with 85 per cent magnesia which in turn is protected with heavy canvas, well painted, the radiation loss is small and seems to just about make up for the loss of water which would result from water at high pressure being flashed into steam at a lower pressure.

These remarks are not offered as a sales argument for an accumulator, but are intended to convey to the reader the writer's impression and observations on the application of accumulators to industrial power plants. It should also be borne in mind that the accumulator is not a "cure-all" for improper conditions in the production and use of steam, but that these conditions must be studied and corrected just as much as if the accumulator was not a part of the system. Further, in the operation of the accumulator no particular attention should be paid to the pressure within the accumulator, but the firemen's efforts should be directed toward maintaining a constant firing condition.

The accumulator itself contains no moving parts and should require no attention other than an occasional inspection, the same as would be given to any pressure vessel. The moving parts connected with an accumulator installation consist only of an oil pump which supplies the necessary pressure to operate the automatic valves, which the manufacturer chooses to call a "steam switch board." To anyone familiar with the oil relay valve gear used on steam turbines this should present no mysteries as the two function very much the same.

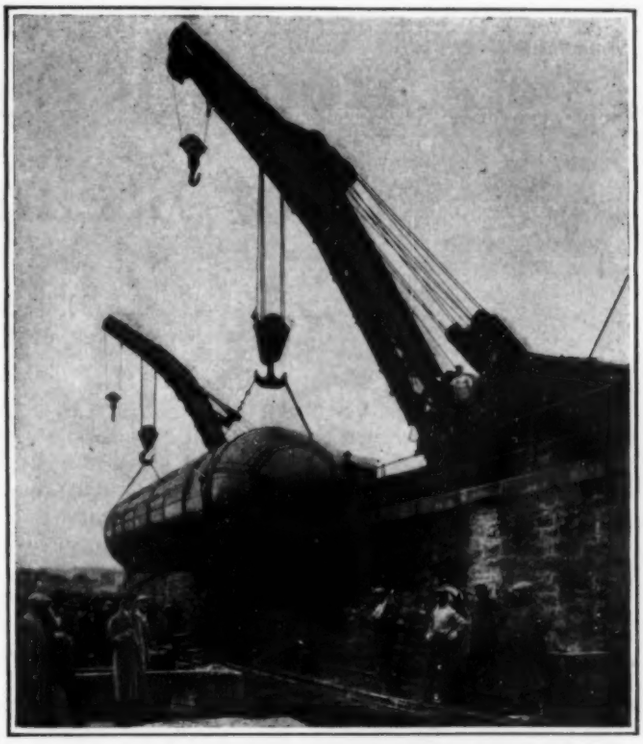


Fig. 2—Unloading an Accumulator, Showing Construction and Size of a 5,000 hp. Unit

This accumulator is to be used to equalize a steam demand varying from zero to 5,000 boiler horsepower and back to zero in 80 seconds, repeated in a three minute cycle

Van Stone Joints for High Pressures

The most satisfactory method of making a Van Stone joint is to use the flange that will be used in service as a form for rolling the pipe. In this way the pipe will exactly fit the contour of the bore of the flange and prevent any creeping of the pipe while under pressure.

The bore of the flange should be tapered slightly for a distance from the flange face approximately twice the thickness of the pipe and the edge over which the pipe is rolled should have a radius equal to not less than one-half the thickness of the pipe. The tapered part of the bore adds considerably to the strength and safety of the joint as it takes strains which would otherwise come where the pipe is rolled over the flange, and will prevent the pipe from pulling out of the flange in case the belled part should, for any reason, be broken.

Tests have been conducted to determine the proper heat at which steel tubing should be Van Stoned, to give the most satisfactory results, and it was found that the rolling process should be started when the tube is heated to a temperature of 1,800 deg. F. and should be stopped when the temperature of the tube reaches 1,350 deg. F. If rolling is carried below this temperature, there is danger of getting a stratified zone which would impair the strength of the tube. The temperature of the pipe during the rolling process should be carefully watched. The optical pyrometer has been successfully used for this purpose. *(From paper by A. B. Williams and C. W. Welch, Stone & Webster, Inc., Boston, Mass.)*

Automatic Volume Control of Steam and Air

By JOHN WOLFE

Superintendent of Gas Manufacturing, Baltimore Gas, Electric Light and Power Company

EXECUTIVES AND MANAGERS are realizing more and more that they have not done their utmost toward manufacturing a product either uniformly or economically unless they have applied to the process all of the equipment necessary to standardize and duplicate the optimum conditions for that particular process. The chemical engineer knows full well the necessity of maintaining continually such factors as temperatures, pressure and mass or quantity at the proper amounts if he wishes to realize a production as near to the theoretical as possible.

For quite some time instruments have been available for controlling temperatures and pressures. Apparatus has also been developed to accurately weigh and proportion bulk chemicals, coals and liquids. It has, however, been only a short time since satisfactory and dependable devices have been placed on the market for controlling quantities, particularly those which have little ponderable weight, such as steam, air and gas. It is with the application of the latter class of controls that this article will deal.

In order to show the application of this equipment to chemical manufacture, two outstanding examples will be chosen as illustrative of the results which may be obtained. The first example will be one in which the continuous control of air for combustion in steam raising will be used while the second will be an example of intermittent or cyclic control of air and steam for the manufacture of blue gas or carburetted water gas.

In the electrical industry, the necessity for generating

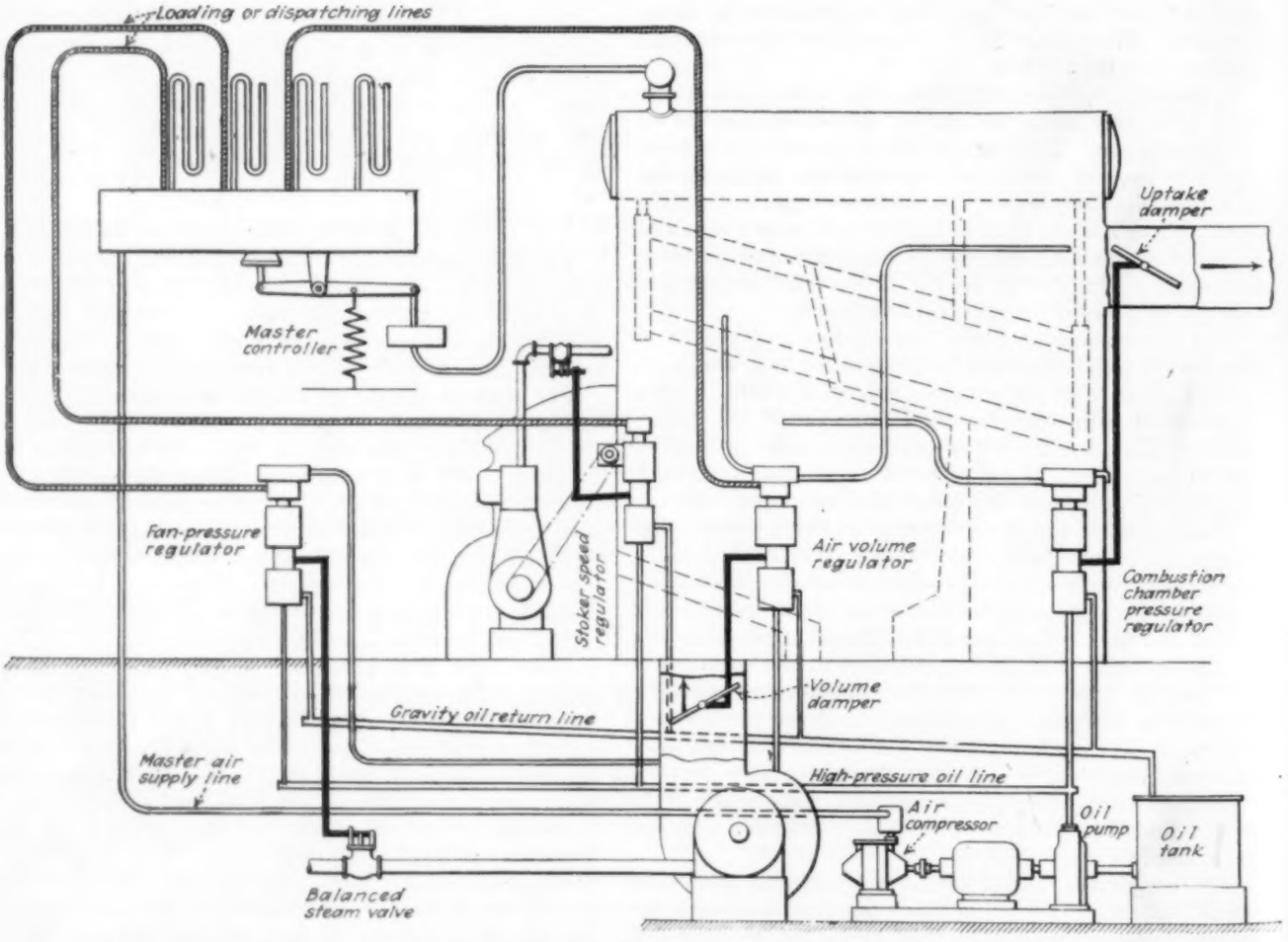


Fig. 1—Diagrammatic Layout of Typical Boiler Installation Showing Dampers, Regulators and Waster Controller

power at the lowest possible cost has caused the power plant engineers to work, among other things, for the production of steam with the smallest possible consumption of coal. This entailed the restriction of the air used in the combustion process to as near to the theoretical amount as the fuel permitted. In bringing this about, a piece of apparatus known as the automatic combustion control was developed. Such a piece of apparatus, if it is to function properly, must definitely establish for every given act of operating conditions, such as steam head or pressure, forced draft pressure, fuel quality and size, and fire bed conditions, a perfect and exact combination of fuel and air. If this is not accomplished, fuel will be wasted, since an excess of air will cause loss of

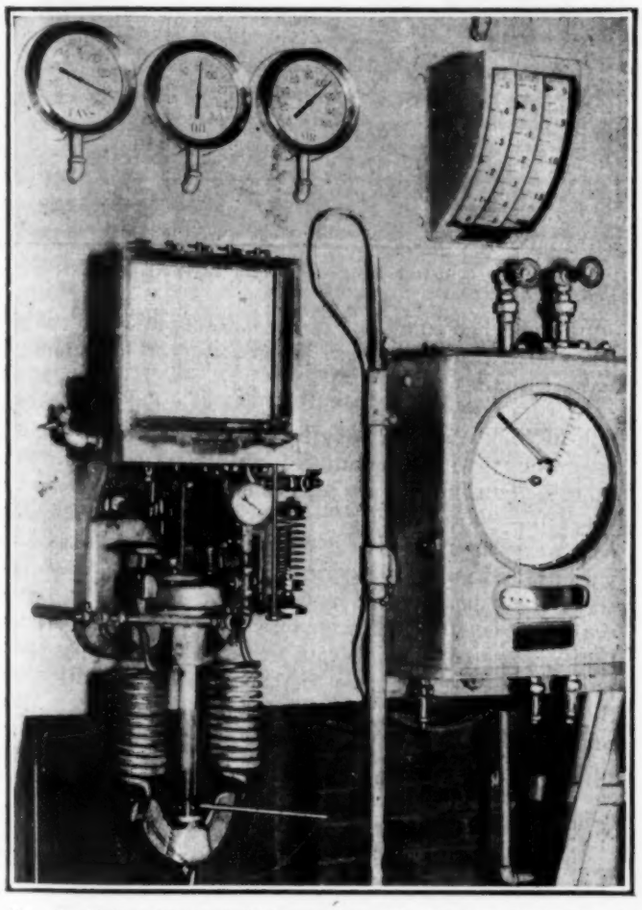
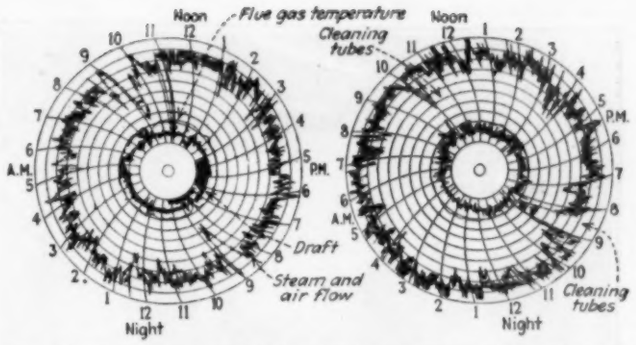


Fig. 2—Boiler Control Instruments with Master Controller at the Left

heat to the stack, while a deficiency of air will result in a loss of carbon monoxide or unburned gas.

In order to secure this perfect and exact combination of fuel and air, a group of rugged and substantial, albeit sensitive, regulators are utilized to control the various pieces of equipment which are standard around the boiler room. These are forced and sometimes induced draft fans, stokers or coal burners, and dampers in primary air and stack uptake ducts. A proper co-relation of these various regulators can be secured only by governing all of them from a central point. This is done by utilizing a central or master controller which sends out impulses to each regulator much as a chief dispatcher sends out orders to control the routing of the various trains in his division.

In a properly designed system, each regulator, having received the order from the master controller, proceeds



Figs. 3 and 4—Two Boiler Meter Charts from a Boiler Controlled by a Master Controller

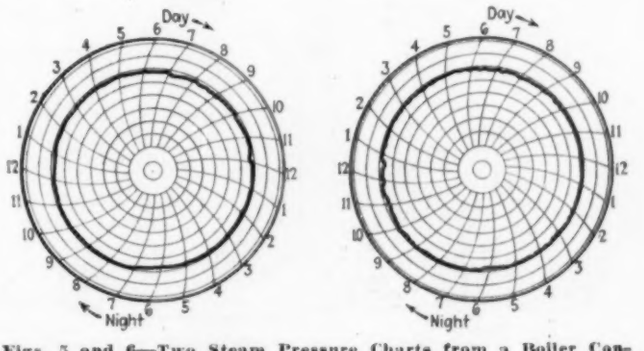
to act in accordance both with this order and with the conditions then governing the element under its control. Thus if the master controller receives an order for increased steam demand, it sends out an order for more fuel and air for combustion. As a result, in a stoker-fired plant, the stoker speed regulator would adjust the rate of fuel input to coincide with the demand by adjusting a rheostat or steam valve to speed up the stoker. Likewise the forced-draft fan regulator would speed up the fan, the undergrate air damper would be set by the air volume regulator and the uptake damper by its regulator. All of these settings would be made to duplicate ideal combustion or "test" conditions.

The remarkable part about such automatic apparatus is that it is continually "on the job" and constantly readjusting, resetting and rechecking itself in every phase to meet all of the multitudinous fluctuations and variations encountered in operating a steam boiler. The most expert fireman might have given his attention to only one of these factors for a short period of time when some other factor would demand his atetntion. It is humanly impossible for a man, however, to furnish the continuous adjustment and supervision which can be contributed by an automatic combustion control.

The proof of the satisfactory operation of and results obtained by such devices is to be found in the evaporations obtained in the boiler houses which have installed them and in the rapidly growing number of installations.

In order to make clearer the appearance and use of these devices, a number of photographs and cuts have been made to illustrate this part of the article. Thus Fig. 1 shows a diagram of a typical boiler installation with the regulators indicated at the proper points. The master controller, which may operate one or more boilers, is also shown on the left side of Fig. 2.

The operation of the stoker fan regulator is adjusted by the air volume regulator, shown in Fig. 7, while the final adjustment is made by the uptake regulator.



Figs. 5 and 6—Two Steam Pressure Charts from a Boiler Controlled by a Master Controller

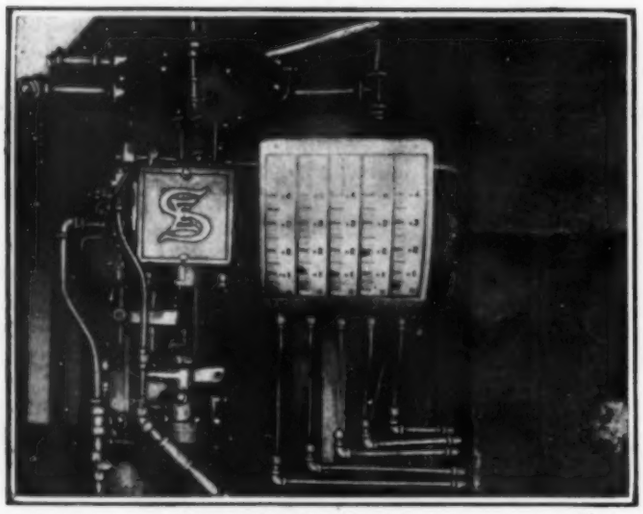


Fig. 7—Air Volume Regulator

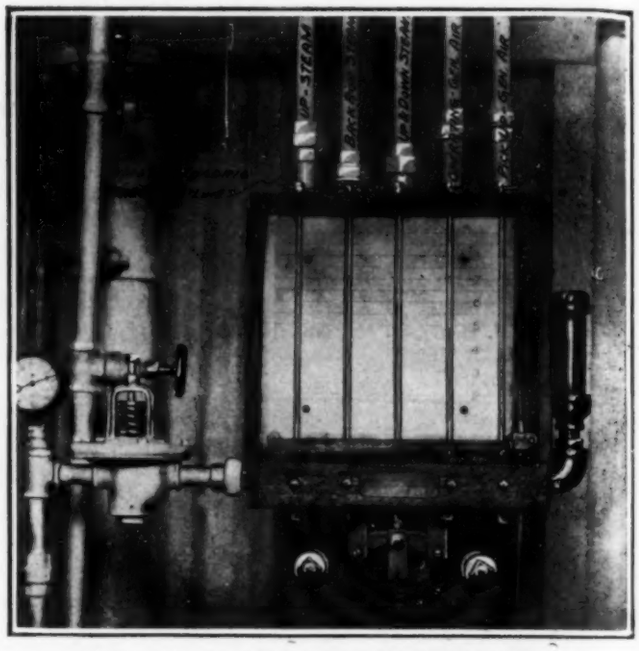


Fig. 9—Master Controller With Dispatch Piping

The writer knows, from personal experience, that such an automatic combustion system will assist in producing uniform evaporations day in and day out under severe load fluctuations. This statement is of necessity based on a fuel of uniform heating value. As proof of the last statements Figs. 3 and 4 are shown which are the boiler meter records from a controlled boiler. On those charts the point of maximum economy and efficiency is indicated when the two outer lines, which represent the steam production and hot gas flow through the boiler setting, are close together. These charts show how satisfactorily the work is being accomplished by the regulators while a uniform steam pressure, as shown in Figs. 5 and 6, is being maintained.

A very good example in the volume control of both steam and air, as applied to intermittent or cyclic control, is in the manufacture of blue gas or carburetted water gas. In this process, air and steam are alternately admitted to a fuel bed. The air is used to "blast" and heat up the fuel bed to a state of incandescence so that it will react later with the steam to produce carbon monoxide and hydrogen.

In order to produce the largest amount of gas per unit of fuel, it is necessary to closely control the cycle of operations and the quantities of materials used. The control of the time cycle was established some years ago when the "automatic gas maker" was invented. This determines the period and frequency of operation of the various hydraulically operated valves on the water gas set. These periods are usually set in minutes and fractions thereof. It has been only recently, however, that the volumes of air or steam delivered in any particular portion of the cycle have been under control. Although the timing of the operation of an air valve or steam valve might be very exact, there formerly was nothing to insure the delivery of the proper quantity of the air or steam, the resistance of the fuel bed, which may fluctuate over a wide range, or the back pressure of the equipment beyond

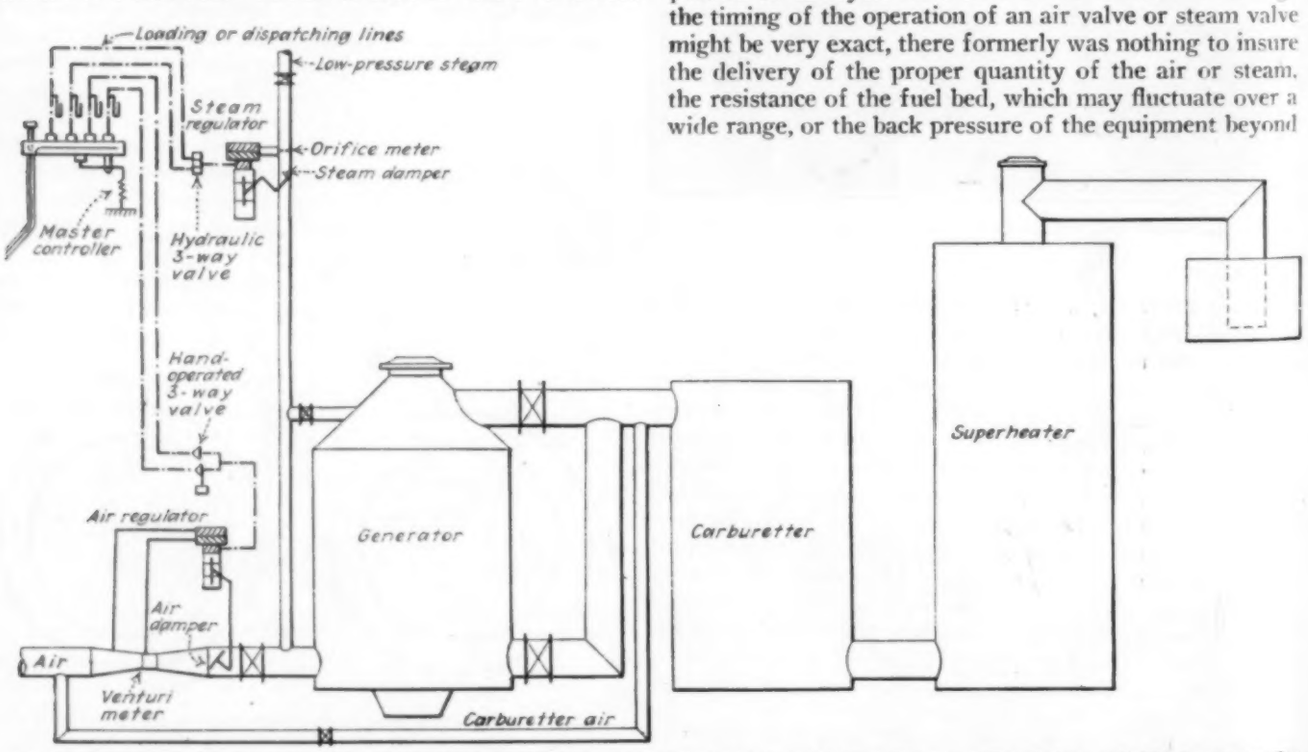
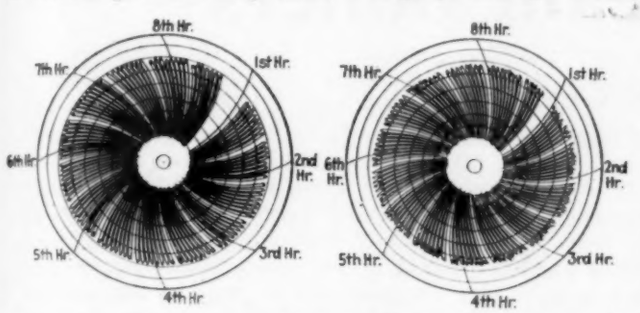


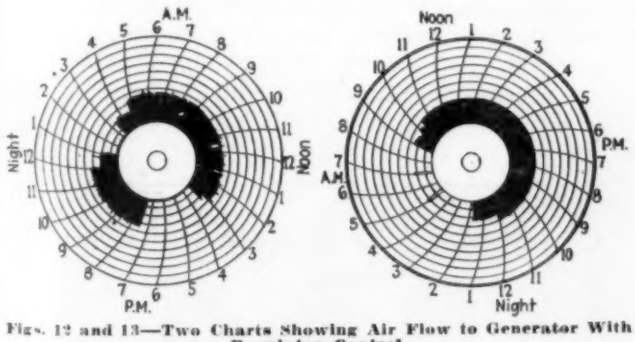
Fig. 8—Diagrammatic Layout of a Carburetted Water Gas Set Showing Air and Steam Dampers, Regulators and Master Controller

the generator fire. It is particularly necessary to control the steam when it is being delivered from low pressure or "exhaust" steam mains. In this case a small variation in header pressure may mean a large percentage variation in the volume of steam delivered, because the ratio of the variation to the total pressure is large. Also, where the air is delivered by the manifold system from air blowers operating in parallel, the higher pressures will deliver disproportionately large amounts of air to the sets with low pressure resistance fuel beds while the sets with the high resistance beds will receive volumes of air much too small to maintain the proper fire conditions. A study of the factors involved was made and automatic volume control equipment was installed to offset the influence of the factors listed above.



Figs. 10 and 11—Two Charts Showing Steam Flow to Generator With Regulator Control

A regulator was installed to control a butterfly damper in the steam line to each set as well as another regulator and damper for the air or "blast" to each set. These regulators are governed by measuring the amount of air or steam flowing through an orifice or past a Pitot tube placed in the line and utilizing the pressure drop across the orifice or tube tips to counterbalance against a certain pre-established loading or weighting. This loading may be accomplished by using adjustable weights or, better, by air pressures from a central loading device or master controller. The regulators will then set themselves to maintain definite volumes or rates of flow for the particular portion of the cycle during which they function.

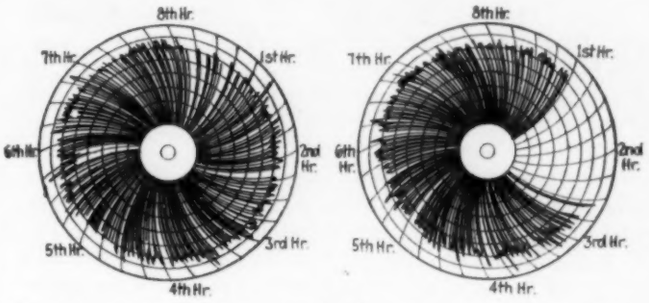


Figs. 12 and 13—Two Charts Showing Air Flow to Generator With Regulator Control

Several uses to which the master controller may be put and which will illustrate the desirability of its use follow.

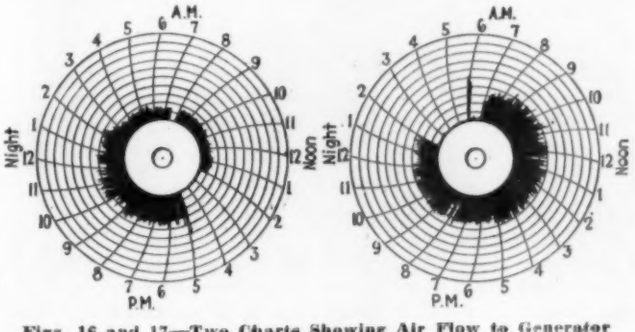
It is desirable to establish reduced rates of air and steam flow at the beginning and end of the period over which a water gas set may operate. Thus, when the set is first put into operation after a "shut down" or "clean," the fuel bed is thin and cold and reduced quantities of both air and steam are desired. As fuel bed conditions improve and the thickness of the fire increases, the volumes of air and steam are increased accordingly. Toward the end of the operating period and shortly before removing the ash, the active fuel bed has been much reduced in thickness, because of the accumulation of ash, and it is desirable to again reduce the amounts of air and steam admitted. Also it is necessary at times and particularly with certain fuels to admit the steam, which is forced down through the fire, at a higher rate than that sent through as "up" steam. All of these changes may be easily and accurately made by providing the proper loading or dispatch lines from the central master controller to the individual regulators. The operation of any number of sets may be controlled in this way.

It has been found that by using the regulators as outlined above, more uniform production of a better quality gas is maintained and this for a longer period. Also the fire conditions, particularly as regards uniformity for clinkering, have been improved. Without the use of these regulators some fires would run very hard and others very soft. Even with longer operating periods, the fires were no more difficult to clinker when using this control. Operating temperatures throughout the set were also maintained with a greater degree of uniformity. This resulted in the securing of an increased efficiency in oil cracking when carburetting the gas. This was because the optimum temperature conditions were always maintained for the oil cracking process.



Figs. 14 and 15—Two Charts Showing Steam Flow to Generator Without Regulation

A series of figures will illustrate the application of the automatic control to a water gas set. Fig. 8 shows an outline drawing of a carburetted water gas set and the location of the air and steam dampers with their regulators connected to a master controller. As many as eight sets or sixteen regulators have been connected to one of these master controllers. Fig. 9 is a photograph of a master controller with the dispatch piping labeled to indicate its use. Figs. 10 and 11 are charts from a steam flow meter and Figs. 12 and 13 from an air flow meter and indicate the uniformity with which steam and air are supplied to the fuel bed when using the controller and regulators. Figs. 14 and 15, also Figs. 16 and 17 show respectively the steam flow and air flow without regulation and indicate the irregularity of flow.



Figs. 16 and 17—Two Charts Showing Air Flow to Generator Without Regulation

Gas-Fired Steam Boilers

By Alexander B. Greenleaf
Peoples Gas Light & Coke Company, Chicago, Ill.

INCREASING UTILIZATION of gas-fired steam boilers for industrial purposes has caused a study of the economics involved. Gas boiler installations have increased in a manner parallel with the growth in the use of gas as an industrial fuel, which, it is said, has increased 1,000 per cent in the past ten years.

Despite the seemingly high cost of gas as compared with other fuels, gas-fired steam boilers are being used with highly satisfactory results for many purposes. In such uses they are not regarded primarily as a device for saving money, but are coming to be recognized as an actual paying investment.

There is nothing new about gas-fired boilers. Essentially they are the same as any other fuel-fired, steam-generating equipment. But it has taken a long time for an appreciation of the basic economics back of this equipment to develop. Many cash disbursements made by industries are regarded as capital investment rather than expense. Advertising, for example, is regarded by many as a capital investment. It is reported that at least one chemical plant regards employees' salaries, for the first year, as capital investment. Many other things are now acknowledged to belong in this category, one of them being gas-fired boilers.

Fig. 1—Gas-Fired Steam Boiler Used in Water Distillation in a Chicago Chemical Plant
This equipment, which is automatic, enables the plant to have on hand at all times an ample supply of distilled water at a low cost.

A firm of consulting engineers has made more than ten analyses of the use of gas-fired steam boilers in Chicago plants. In every instance the cost of gas for fuel exceeded the cost of the fuel previously used, but in every instance the unit cost of heat in the product was substantially less than it had been with the fuel formerly used. In one instance costs were reduced 278 per cent through the use of gas. It is for such reasons the gas-fired boilers are considered as a capital investment.

Gas-fired boilers are most often used where for some reason it is not feasible or economic to install the usual type of power plant. The choice largely depends on the relation between electric load and process steam load, and will not be discussed in this paper but is covered elsewhere in this issue.

Some cities will not permit the use of an open-flame boiler in plants in which there is likely to be combustible vapors or gases in the atmosphere. In such places an enclosed flame boiler is required or a separate boiler room must be built. Gas-fired boilers designed for use in such places are now obtainable. In these the flame is completely inclosed. The air for combustion is taken from outside the building through a pipe. A spark plug is used to ignite the gas. Thus fumes within the building cannot come into contact with the flame. A Pyrex window for observing the flame, a spark coil, a spark plug and the air intake are provided with these boilers, which are inspected according to the provisions of the A.S.M.E. code.

Steam is used in many different ways for heating

Fig. 2—Gas-Fired Boiler Provides Steam Jet for Cleaning
A novel use for this equipment is in supplying a jet for a cleaning fluid, where such a fluid is of a flammable nature.

operations: by means of jacketed kettles, coils of pipe in open space or immersed in solutions; or steam is blown directly into the solution where additional water, formed by condensation, is permissible.

There are two principal types of gas-fired steam boilers in general use. The cast iron type is limited to use for comparatively low pressures, while the steel fire-tube type can be used over practically the entire range of working pressures. These two general classes might be subdivided further according to other characteristics. The average efficiency varies from 65 per cent in the smaller sizes, below 5 hp., to 75 per cent in the larger sizes of 10 hp. and over.

The hourly gas consumption of a boiler of a given horsepower, having an efficiency of K, expressed in percentage, may be figured as follows

$$\frac{33{,}479 \times hp. \times 100}{K \times H} = \text{cu.ft. per hour per hp.}$$

where: 33,479 = number of B.t.u. absorbed in water and steam, or the evaporation of 30 lb. of water from a feed-water temperature of 100 deg. F. to 70 lb. per sq.in. gage steam pressure, or the latent heat of evaporation of 34.5 lb. of water at 212 deg. F.

K = efficiency of boiler expressed in per cent

H = B.t.u. per cu.ft. of the gas.

This same formula becomes useful in determining either the efficiency of a boiler or its horsepower, when the remaining three factors are known;

$$\text{Efficiency} = \frac{H \times \text{cu.ft. of gas consumed}}{33{,}479 \times hp. \times 100}$$

$$\text{Horsepower} = \frac{K \times H \times \text{cu.ft. of gas consumed}}{33{,}479 \times 100}$$

The horsepower required to supply one square foot of copper-jacketed kettle surface, submerged in water of various temperatures, with 10 lb. steam pressure (temperature of steam 240 deg. F.) is as follows:

Temp. of Water	Temp. Difference of Steam & Water	Horse Power Required
190°	50°	.48
165°	75°	.96
140°	100°	1.45
115°	125°	2.16
90°	150°	2.92
65°	175°	3.65

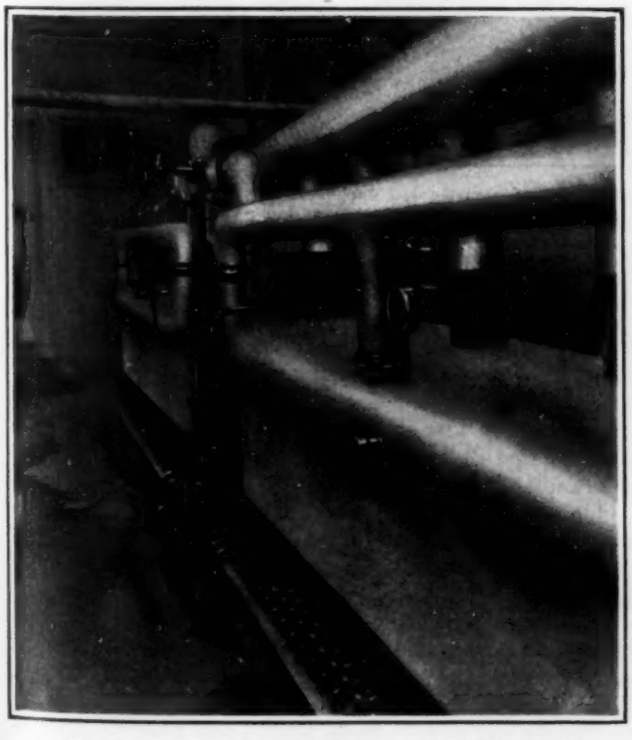


Fig. 3—City Gas Proved Cheaper Than Scrap Fuel
These boilers, fired with city gas, are in a large lumber mill, where the cost of preparing wood scrap for fuel has been found to exceed the cost of gas fuel.

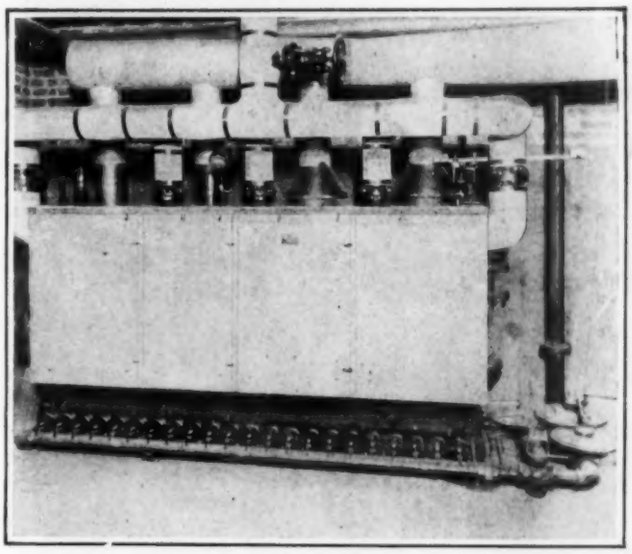


Fig. 4—Large Gas-Fired Steam Boiler in a Chemical Plant
In this plant, by increase the load by heating the buildings with steam, as well as producing steam for processing, a greatly reduced gas rate was obtained.

Actual tests on a 50 gal. copper kettle gave the following data:

	Test No. 1	Test No. 2
Initial temperature of water	72° F.	81° F.
Final temperature of water	212° F.	212° F.
Temperature rise	140° F.	131° F.
Weight of water heated	400 lb.	400 lb.
Gallons of water heated	48	48
B.t.u. absorbed in water	56,000	52,400
Steam pressure	10 lb.	70 lb.
Steam temperature	240° F.	316° F.
Time required	42 min.	9 min.

The latent heat of one boiler horse power is at:
10 lbs. Steam pressure—952 × 30 = 28,560 B. t. u.
70 lbs. Steam Pressure—897 × 30 = 26,910 B. t. u.

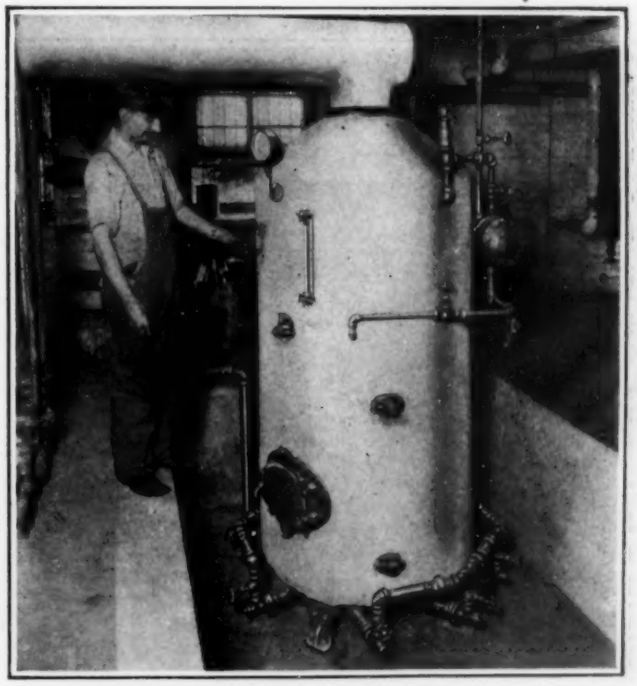


Fig. 5—Gas-Fired Boiler in a Cocoa Factory
This boiler is fully automatic, the fuel is throttled inversely to the steam pressure, and the minimum of attendance is required.

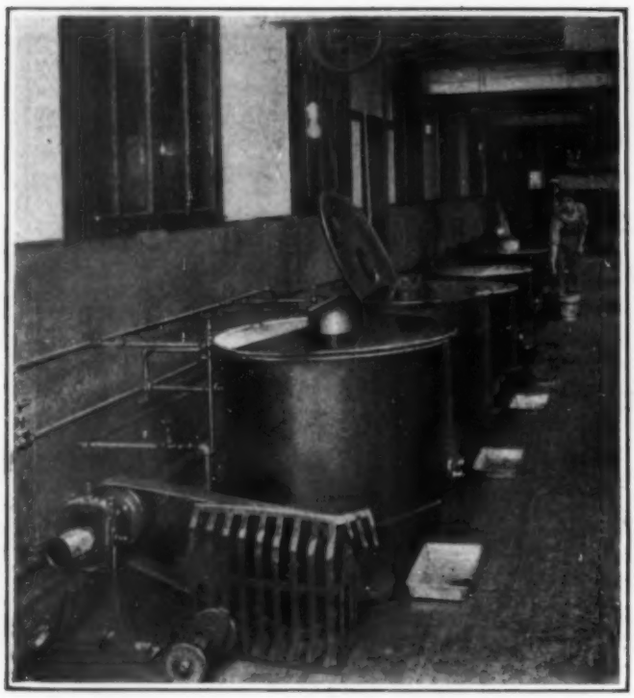


Fig. 6—Copper-Jacketed Kettles Heated With Steam
This equipment is supplied from the automatic gas-fired boiler shown in Fig. 5.

To supply 56,000 B.t.u. to be absorbed in the water requires approximately 2 hp.-hr. To this should be added 25 per cent for losses by radiation. It follows that a 50 gal. copper jacket kettle to boil water continuously every forty-five minutes with 10 lb. of steam pressure requires a 3½-hp. boiler. To boil water continuously every ten minutes with 70 lb. steam pressure requires a 16.6 hp. boiler. In practice, it has been found that the time required to charge and discharge the material boiled gives the boiler a chance to recuperate. For fast work a 12 hp. high pressure boiler to furnish steam to a 50 gal. jacket kettle, or a 4 hp. low pressure boiler for slow work, is recommended.

Fig. 7—Another Type of Gas-Fired Boiler in a Chemical Plant

The conversion of coal-fired boilers to gas fuel is very bad practice and should never be done except in the most extreme cases. In no such instance will as high an efficiency be secured as would be the case if a new boiler, designed to burn gas, were installed. The reason a coal-fired boiler cannot be thus converted is that the cross-sectional area of the flues is much too great in a coal boiler for the products of combustion generated by a gas flame. When gas is burned under a coal boiler there is less restriction to the passage of the hot gases and these, therefore, leave the boiler at too high a temperature, without having given up sufficient of their heat for the best economy.

The smoke problem in cities is increasing in seriousness year after year. City residents are encountering unduly large laundry bills. Physicians tell of the deleterious effect of smoke upon human life. One has only to glance at our cities any day to see the horrible pall of smoke hanging overhead. And yet very little is done about it. Fines are paid and the smoke continues. "Some day"—the use of soft coal in cities will come to an end and conditions will be improved.

A large portion of Park Avenue in New York City was transformed from the depths of despair to one of the finest streets in that city when the New York Central railroad was electrified. The increased value of the property adjacent to the railroad, it is said, would pay for the

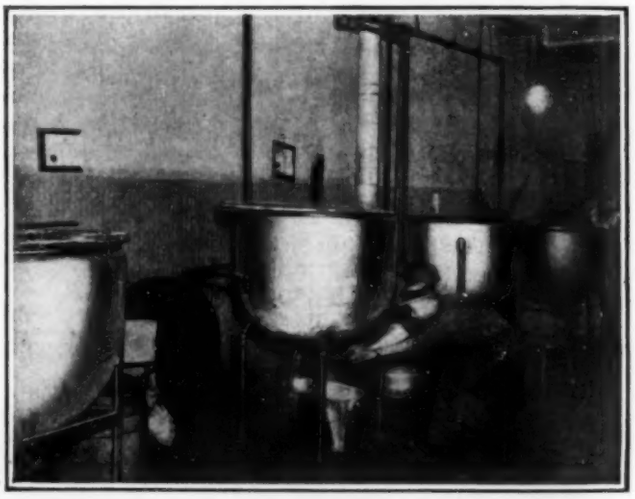


Fig. 8—Steam-Heated Jacketed Kettles Supplied from a Gas-Fired Boiler

electrification many times over. This is just one phase of the high cost of burning soft coal. There are many others. Meantime, more and more gas-fired boilers are being sold every year. The consumption of city gas in this type of appliance is very large. This type of boiler is one of the most satisfactory pieces of equipment ever designed. The wise chemical engineer will always investigate gas fuel in connection with his problems of steam generation.

One particularly advantageous application of the gas-fired boiler remains to be mentioned. The water in sprinkler systems must be kept from freezing in winter if such systems are to be depended upon to give the protection for which they were installed. This can readily be done by means of a small automatic gas-fired boiler. In two installations of this type, each with 25,000-gal. water storage tanks, the yearly cost for gas of such an installation has proven to be $82.18 and $127.48, respectively.

Steam Metering and Control

By H. M. HAMMOND
Bailey Meter Company, Cleveland, Ohio

THE PRIMARY REASON for installing steam flow meters and other power plant instruments is to visualize operating conditions, thereby giving the operators sufficient information to enable them to control boilers, turbines, processes, etc., economically and safely over long periods of time.

In addition to the steam or fuel saving, there is usually a saving in labor, especially in the boiler plant, due not only to the smaller amount of steam required, but also due to the smaller amount of coal, oil or other fuel to be handled for a given amount of steam produced.

The increase in boiler operating efficiency, as well as the improved economy in steam distribution resulting from the installation of meters, in many cases postpones or eliminates the necessity for enlarging the power plant. This reduction in overhead should be credited to the metering equipment.

With the wide range of mechanically and electrically operated steam metering equipment available today, proper instruments may be provided to permit the operators to analyze conditions and performance and intelligently control boilers, machines and processes. Meters may be designed to indicate, record and integrate the rate of flow, and to indicate or record additional factors such as steam pressure, superheated steam temperature, draft, turbine speed, paper machine speed, etc., on the same chart with the rate of flow. With these graphic records showing the quantities of steam used and other conditions such as temperature, pressure and speed constantly before them at all times, the operators and attendants can use more skill in their work and the information will enable them to produce better products.

Steam meters have been of great importance in supplying reliable data for maintaining accounting systems. The accounting is far more accurate when the actual quantities of steam and power consumed are known. This is especially true where several kinds or grades of product are manufactured. The meters not only provide information for making a fair and proper distribution of these costs, but by charging each department or each operator with the exact amount of steam used at a proper cost rate, wasteful and careless use of steam is avoided. As a matter of fact, one of the greatest fields for steam meters is on lines leading to the various processes or departments of a manufacturing plant. Experience shows a surprising falling off in steam consumption per unit of output where the steam to each department is metered and charged against the cost of operating that department.

Meters recording steam flow and air flow should be installed on each boiler, not only to show the distribution of the load on the boiler, but to guide the firemen in controlling the rate of fuel feed, air supply, etc., to generate the required amount of steam most efficiently.

A certain amount of air is required to burn a pound of fuel. Each pound of such fuel, when properly burned, evaporates so many pounds of water so that a definite amount of air should be used to generate each pound of steam. Either too much or too little air means poor efficiency and usually causes a lower capacity than if the right amount of air were properly supplied.

The meter which indicates and records the rate of steam flow from the boiler, records the rate of air flow to the furnace, and the average temperature of all the gases leaving the boiler, is intended primarily to serve as a guide to proper operation of a steam producing unit. For best operation, each boiler should be operated at the proper capacity to carry the load on the plant, and fuel and air should be supplied to each boiler furnace in proper proportion to produce this capacity with the minimum over-all loss. The boiler operator maintains the boiler at the proper capacity by observing the steam flow record produced by the meter. By observing the relation of the steam flow and air flow pens on the boiler meter chart the operator is able to control the supply of fuel and air to each boiler so that it will produce steam in the most economical manner. When properly adjusted, the steam flow and air flow pens of the meter will be together when the minimum combined loss to excess air, CO, refractory deterioration, ash-pit and smoke exists.

The record of flue gas temperature which is given by the meter is at all times a dependable check on the condition of the boiler baffles, and on the efficiency of the heat transfer through the boiler tubes. It shows whether or not the heating surface is absorbing the maximum amount of heat possible at all times.

These meters, when installed on all boilers in a plant, will show which boilers are loafing. They will indicate undesirable conditions and poor operation, such as a thin fuel bed, leaky boiler settings which admit excess air, defective baffles, insufficient draft or incorrect wind

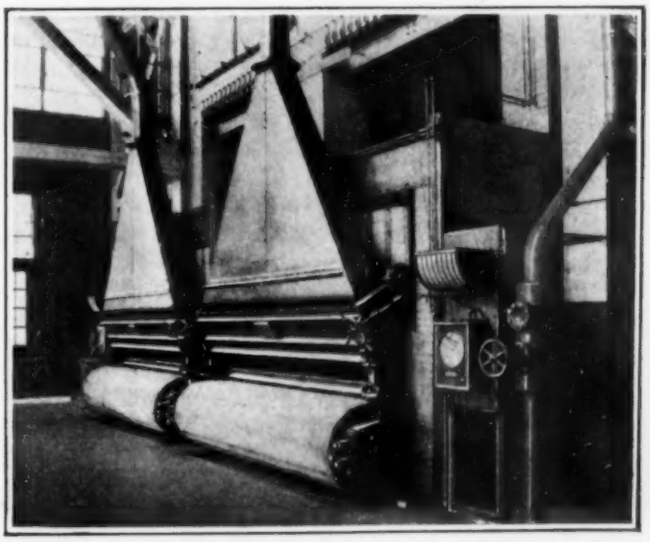


Fig. 1—Control Instruments on Boilers in an Industrial Boiler Plant

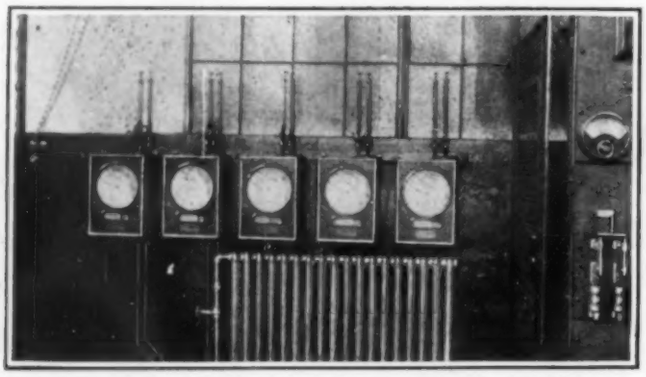


Fig. 2—Flow Meters Showing Steam Flow to Turbines, Auxiliaries and Processes

box pressure, poor feed water regulation, dirty tubes and other points which are detrimental to best efficiency.

Steam flow meters should be installed on all distribution lines so that the steam costs can be allocated to the proper departments, machines and processes, thereby giving a fair basis for an accounting system and incidentally furnishing an incentive to the various departments to reduce these costs. The steam consumption of turbines, pumps, evaporators, steam stills, digesters, heating systems and various processes in the industrial plant is essential information for power plant operation and control if best results are to be obtained.

In large industrial plants where there is a wide variety of uses for steam and where a large number of steam consuming machines are fed from a single boiler house, the amount used by each machine or for each process is measured and charged in as a part of the cost of the product. This insures that all departments will use steam economically. The total steam consumed when compared with the amount generated by the boilers, and when compared with the plant production, will show up excessive losses due to leaks, faulty operation of traps, valves, etc., excessive radiation losses and other sources of waste.

The superintendent of a large industrial plant recently remarked that his meters were paying for themselves every two weeks. Before meters were installed they had no idea how much steam they were producing or where the bulk of this steam was being used. The steam costs were high and practically uniform regardless of plant production. This seemed unreasonable. Boiler meters were installed on the boilers, and fluid meters were installed on the steam and water lines to every department. Now each department is charged with the steam it uses and when production falls off they expect to see a decrease in steam consumption as well.

In the paper industry fluid meters have shown a tremendous saving when installed on steam lines to the digesters in the paper mills. In cooking practice the steam flow meters not only record the rate at which steam is being used, but they are of great assistance in working out better cooking methods and they aid in improving the quality of stock.

Steam is used not only to raise the temperature of the liquor and chips to the point where digestion takes place, but it also serves to create circulation in the digesters. An integrating and recording meter installed on the digester will show the total amount of steam used over a given period of time, and will also record the rate at which it is used, thereby providing sufficient information for controlling the steam supply so as to maintain uniform cooking operations.

If such factors as strength and temperature of the acid, moisture content of the wood, quality of the chips and other factors are substantially the same, it will be possible to produce a uniform product by following the same method for each cook, using the fluid meter as a guide for control. Meters will be found extremely valuable in reducing the steam consumption of digesters by indicating the proper methods of control to give the best quality of stock with a minimum quantity of steam.

The use of flow meters on paper machines to measure not only the steam consumed by the machines themselves, but also the steam supplied to the paper machine auxiliaries, has been an important step in improving control and reducing costs. In one instance where a machine was driven by a steam turbine and most of the drying was done by the exhaust steam from the turbine, considerable trouble was experienced, resulting in a non-uniform quality of paper. Irregularities in the steam flow record of a meter on the steam line to the paper machine auxiliaries was investigated and found to coincide with the dumping of a large steam trap. Due to incorrect manipulation of valves in the steam lines to the trap high pressure steam from a point ahead of the turbine nozzle was being fed to the steam trap. This resulted in a variation in turbine speed every time the trap dumped and the paper produced was not of uniform quality. This condition would probably have gone undetected for some time had it not been for the operation of the meter, the irregularities of which were synchronized with the dumping of the steam trap, giving the operator a clue which led to detection of the trouble.

Fig. 1 shows a boiler meter and a multi-pointer draft gage installed on each of two 800 hp. boilers fired with forced draft chain-grate stokers in an industrial plant. The boiler meter indicates, records and integrates the steam flow, and records air flow and flue gas temperature, while the gage indicates wind box pressure, various stoker compartment pressures and furnace draft. This equipment shows exactly what the operating conditions are at every instant and furnishes the necessary information to enable the boiler operator to correct faulty conditions.

Several steam flow meters measuring the rate of flow of steam, as well as the steam pressure to turbines, auxiliary machinery and processes are shown in Fig. 2. This equipment provides the necessary records for accurately controlling the distribution of steam in this factory.

Electrically operated fluid meters are particularly

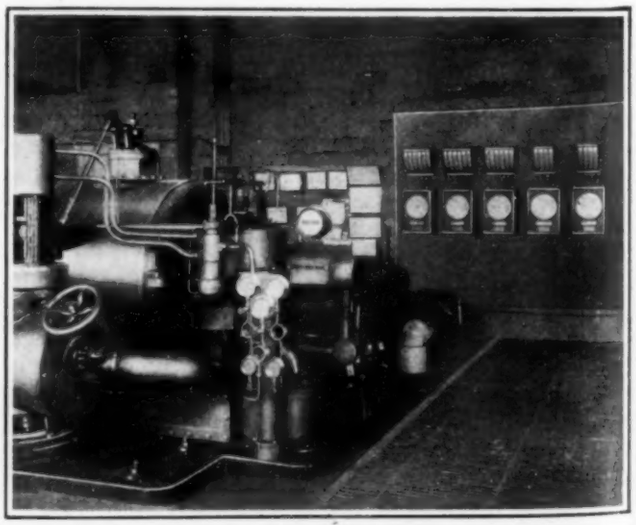


Fig. 3—Meters Used With Waste Heat Boilers in a Cement Plant

adapted to centralized control, or where it is desirable to have the recording and integrating instruments all located at one central point, even though the lines through which the flow is to be measured are scattered throughout the plant.

An installation of meters used in guiding the operation of waste heat boilers in a large Middle Western cement plant is shown in Fig. 3. The meter board in the background of the turbine room sets flush with the wall and supports equipment valuable for waste heat boiler control. The fluid meters at this plant are used to record and integrate the rate of steam generation, and in addition they also record the steam pressure, steam temperature and feed water temperature leaving the economizer. A meter for the measurement of feed water is included, which also records the temperature of the makeup water entering the feed water heater, the temperature of the feed water leaving the heater and the temperature of the condensate. Multi-pointer gages indicate the draft at each pass of the boiler, at the outlet of the cement kiln and at the fans.

In the operation of water gas sets accurate information as to the quantity of steam used, the amount of air blast to the generator and the amount of air blast to the carburetor, as well as the air, steam, oil and other pressures are greatly to be desired. Such information is of extreme value to the operators in controlling the gas making units, and to those responsible for the maintenance of high operating efficiency in the plant. The quantities of steam, air and oil used, as well as the time required for the blow and make in a gas cycle depend somewhat upon the characteristics of the water gas set, as well as upon the kind and size of generator fuel. The magnitude of these factors, however, can be determined by tests when the equipment is first placed in operation so as to get best results in the finished product. After the proper pressures, rates of flow, etc., have been determined for best efficiency, the installation of indicating steam flow meters, air meters and indicating pressure elements enable the operators to repeat the good conditions every day, thereby making a better quality of gas and obtaining maximum production at all times with the best economy.

Fig. 4 shows a gravity recorder and a weir meter installed on black liquor at one of the mills of a large paper company in New England to serve as operating guides and to provide records of soda mill performance. The gravity recorder records the specific gravity of the black liquor entering the evaporator and aids the operators in keeping a uniform gravity of liquor to the recovery department. It permits regulating the amount of steam necessary in the evaporation process so as to maintain the output from the evaporators at a given specific gravity. The weir meter records and integrates the amount of liquor entering the evaporator.

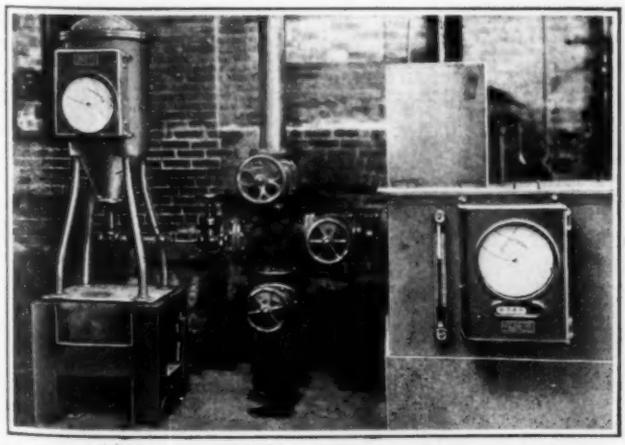


Fig. 4—Flow Meter and Gravity Meter Installed on Black Liquor in a Paper Mill

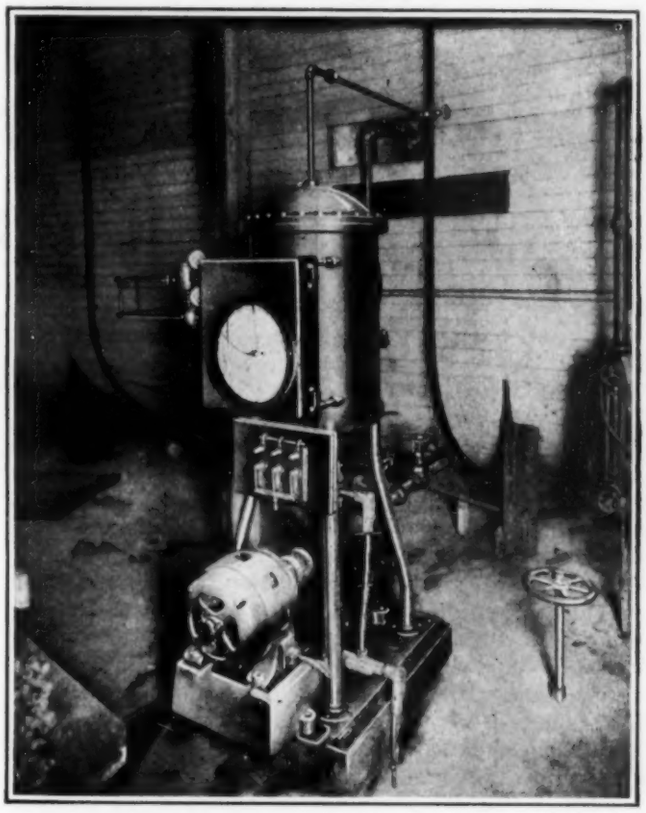


Fig. 5—Gravity Recorder-Controller Installed at a Beet Sugar Factory

Fig. 5 shows a gravity recorder-controller installed on the fifth or last effect of a multiple effect evaporator in a large beet sugar factory. This recorder not only gives the continuous story of the degrees Brix. or specific gravity of the liquor in the last effect, but it automatically discharges the liquor at a uniform gravity to the pan room or next station. This is accomplished by automatically opening a valve in the steam line to the concentrated liquor pump when the gravity in the last effect has reached a predetermined value. As this pump speed is increased and the concentrated liquor is pumped from the last effect, the level of the liquor inside that effect is lowered, thus causing a liquid level controller to open a valve in the liquor line between the fourth and fifth effects. As the diluted liquor from the fourth effect flows into the fifth effect, the gravity is lowered and the specific gravity controller operates to slow down the pump.

The installation of the gravity controller on the last effect of the evaporator insures sending the concentrated liquor to the vacuum pans at as high a gravity as possible so that no steam is wasted. A four-day test run at this plant showed an average of 54.8 boiler horsepower required per ton of beets cut without the use of the gravity recorder controller, whereas a second test run directly following the first one, but with the automatic control system in operation required only 48.5 boiler horsepower per ton of beets, a saving in steam consumption of 11½ per cent.

The Production of Steam From Waste Heat

By A. J. EBNER
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THE WASTE HEAT BOILER, as we know it today, owes its development to the steel industry. This is not surprising, since the manufacture of steel entails tremendous heat losses, the recovery of which could not long be delayed in the face of increasing demands for economical production. The steel plant provides a setting that is ideal for the purpose, the principal factors being continuous operation, demand for steam day and night and exceedingly low furnace efficiency. Under these conditions the installation of waste heat boilers is a most attractive investment.

In an open hearth steel furnace a charge of pig iron and scrap is converted into steel. A wide variety of fuels is available for firing the furnace among which are producer, coke oven and natural gas, fuel oil, tar and pulverized coal. The furnace operates on the regenerative principle, the air for combustion attaining a high degree of preheat. The process involves such high temperatures that efficiency must of necessity be secondary to structural design having protection of refractories as its main object. Heat lost in the stack gases of a well-designed furnace will average between 45 and 50 per cent of the total heat supplied in the fuel. It is quite common to find furnaces with hearth area enlarged for greater steel making capacity, without corresponding increase in regenerator volume, the effect of which lowers combustion efficiency with higher stack temperatures as a consequence. In some cases of this sort stack losses have been found as high as 60 per cent of the total heat input. The chart shown in Fig. 1 is a daily boiler meter record, representative of present-day waste heat boiler performance in open hearth steel furnace practice. This boiler has been in operation since December, 1925, being one of three installed on furnaces rated at 90 tons capacity. On the date recorded the furnace produced 165 tons of steel ingots, with a total fuel consumption of 8,200 gal. oil of 0.934 specific gravity and 19,000 B.t.u. per lb. calorific value. Total steam produced by the boiler in the 24 hours amounted to 278,000 lb. at 125 lb. gage pressure and 90 deg. F. superheat. From the chart the average temperature of gases, leaving the boiler, was 525 deg. F. and the total draft to operate furnace and boiler averaged 3.9 in. water gage. Waste gases from furnace to boiler averaged 80,000 lb. per hour at a temperature of 1,140 degs. F. A summary of operations for the month in which the above chart was taken and covering all three furnaces and boiler units shows the following:

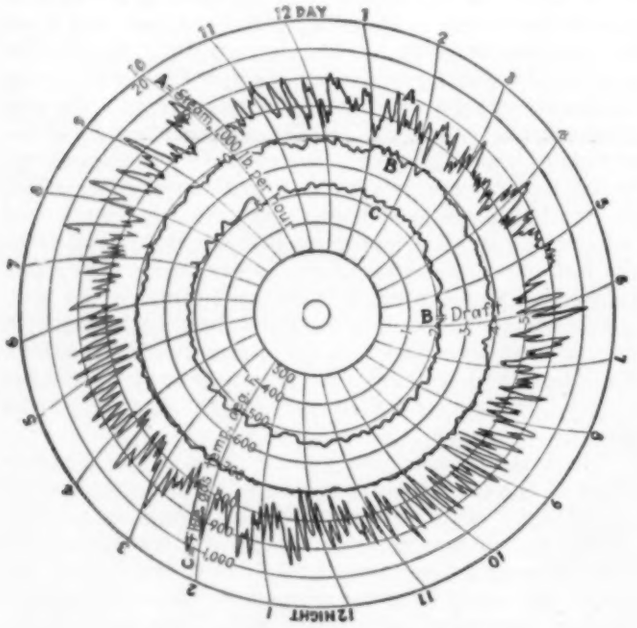


Fig. 1—Chart for Waste Heat Boiler
This chart was obtained from an installation in connection with a 90-ton open hearth steel furnace. Outer line is steam in thousand lb. per hour, middle line is draft and inner line is flue gas temperature.

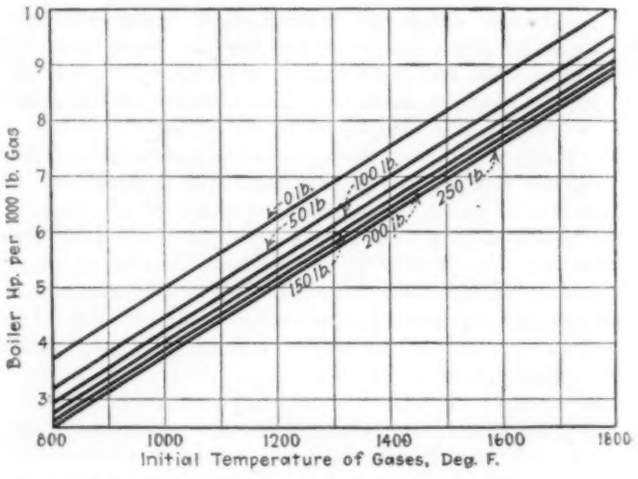


Fig. 2—Heat Recovered by Waste Heat Boilers
These curves show the amount of heat recovery with varying initial gas pressures, at various steam pressures.

OPEN HEARTH FURNACES

Average tons ingots produced—3 furnaces 24 hours	496.2
Average time of heats—tap to tap	12 hr. 5 min.
Fuel oil per ton ingots	49.6 gal.
Draft in stack flue for furnace operation	1.3 ins. W.G.

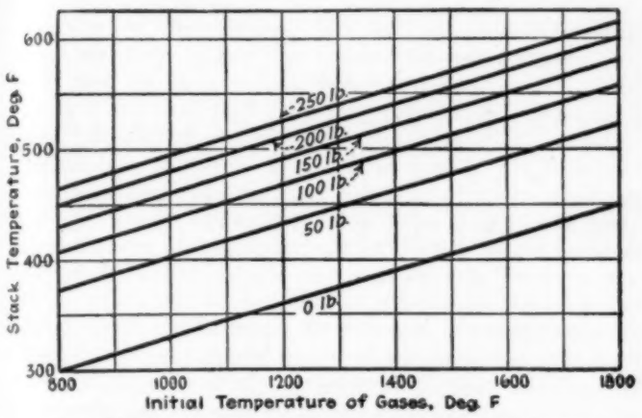


Fig. 3—Effect of Steam Pressure on Stack Temperature
These curves show how stack temperatures increase with increasing steam temperature, at various initial gas temperatures.

WASTE HEAT BOILERS

Feed water temperature	212 deg. F.
Steam pressure	126 lb. gage
Superheat	110 deg. F.
Average temperature of gases to boilers	1,050 deg. F.
Average temperature of gases to stack	492 deg. F.
Average evaporation 24 hours—3 units	816,000 lb.
Evaporation per ton steel	1,645 lb.
Average rate of evaporation—3 units	1,090 B.hp.
Average rate of evaporation—1 unit	363 B.hp.
Average steam per hour to drive induced draft fan and boiler feed pump—1 unit	1,945 lb.
Per cent boiler evaporation to drive fan and feed pump	17.1 per cent

The installation cited above comprises three waste heat boilers of the fire tube type, each boiler having 5,000 sq.ft. of tube heating surface contained in a shell 105 in. inside diameter by 18 ft. long built for a maximum working pressure of 160 lb. per sq.in. The shells are supported horizontally in floor saddles at the furnace charging floor level, and flue connections provided for supplying waste gases from the furnaces. Superheaters are located in the flues ahead of the boilers. After leaving the furnace the products of combustion follow a path through superheater, boiler, induced draft fan and stack. The fans are of the steel plate type driven by steam turbines through speed reduction gears, and furnace draft is under control of the melter who can secure a wide range of draft intensity through regulation of the turbine speed. In this installation the design of boilers was influenced by the possibility of burning producer gas in the furnaces at times when fuel oil would not be available or the market price favored coal. It was further necessary to provide for direct firing of oil at the boilers to insure steam production, regardless of continuity of furnace operation. The economy of waste heat recovery in this case may be judged from the fact that steam generated in coal fired boilers costing $0.37 per 1,000 lb. was replaced by steam from the waste heat boilers costing only $0.05 per 1,000 lb., both figures being exclusive of fixed charges on boiler plant equipment. The three waste heat boiler units cost $110,000 for the complete installation, inclusive of all items necessary for their application to the furnaces. This amounts to $73.30 per rated boiler horsepower.

It has only been since the year 1910 that waste heat boilers have found practical application on regenerative steel-making furnaces. Prior to that time, it was deemed inadvisable to generate steam with waste gases below a temperature of 1,600 deg. F.

The early installations made use of conventional types of water tube boilers, as designed for direct firing of fuel. Experience with these indicated the desirability of higher gas velocities, since in a boiler utilizing waste heat, the transfer of heat from gas to metal occurs almost entirely through convection, whereas in direct fired boilers the greater absorption of heat by radiation materially influences the design. The knowledge gained from these early experiments led to the development of specially designed boilers having the greatest capacity per unit of heating surface with a draft loss held within economical limitations.

It is interesting to note that with increasing knowledge of the factors controlling efficient waste heat recovery, there developed an appreciation of the merits of the fire tube type of boiler for this service. The fire tube boiler is well adapted to provide the essentials of high heat transfer rate by convection and low draft loss. It possesses the advantage of ideal gas travel in that its tubes form straight circular passages which reduces to a minimum the losses due to irregular channels, changes in direction of flow, short circuiting of gas through baffles, and ineffective heating surface. By the use of small tubes, the gases are confined close to the heating surface, and attain a velocity of sufficient magnitude to cause turbulence in the gas stream.

The fire tube boiler has demonstrated its peculiar fitness for waste heat work, and the majority of recent installations in steel plant operation are of this type. It may be set horizontally or vertically, but the preferred form is a single horizontnal shell with tubes of small diameter and relatively great length. As short a connection as possible is made to the furnace stack flue in

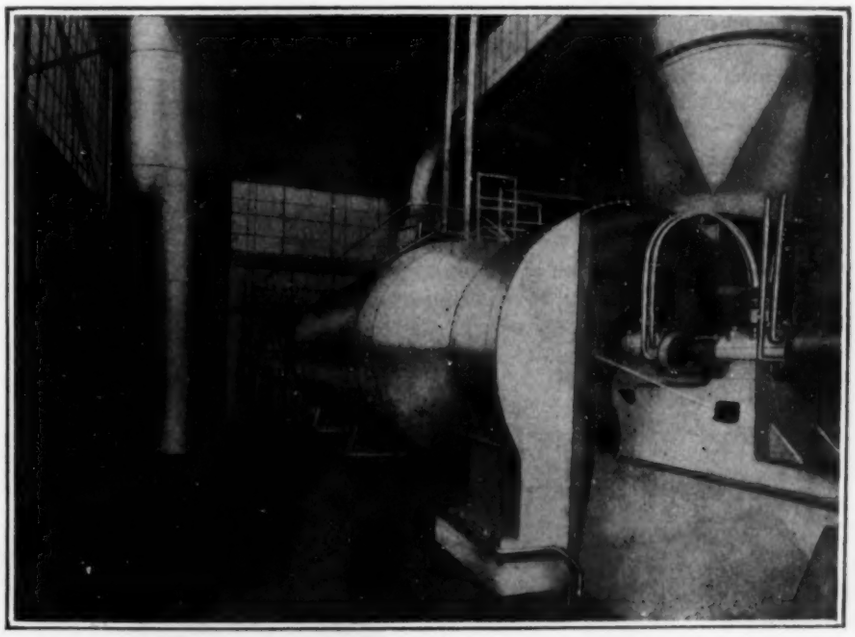


Fig. 4—Fire Tube Waste Heat Boiler
This boiler is installed in connection with a 35-ton open hearth furnace using producer gas for fuel.

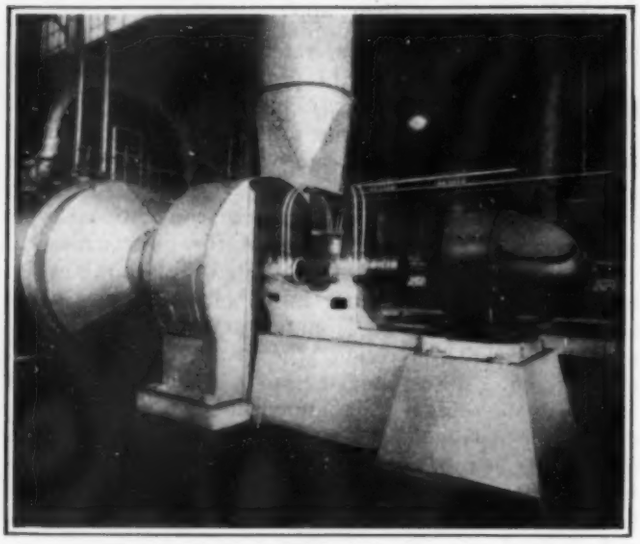


Fig. 5—Induced Draft Fan and Motor Used With Boiler Shown in Fig. 4

order to reduce radiation and friction losses. Where superheat is required the superheater elements are located in the flue leading to the boiler, being exposed to the gases at their highest temperature.

It may be stated as a general rule that under circumstances where gases are liberated from any process at a temperature above 750 deg. F. and where the energy or heat from steam may be usefully employed, a waste heat boiler of correct design will justify the expense of its installation. To determine definitely the savings to be expected demands a close study of all factors pertaining to each particular case. A continuous operation with continuous steam demand will, without question, show an excellent return. Intermittent operation with continuous demand for steam will usually work out well, since the boiler may be arranged for auxiliary direct firing of fuel. When the furnace operation and steam demand are out of step it is difficult to obtain satisfactory economy, unless the price of fuel is unusually high.

The cost of steam fuel has a bearing on how far to go in initial construction costs to secure the maximum economy. Under prevailing industrial conditions the reduction of stack gas temperatures below 450 deg. F. is seldom warranted, since fixed charges on added investment cost will, in general, offset any gain in efficiency. The commonly observed stack temperatures in waste heat boilers are between 500 and 550 deg. F. Economizers are sometimes employed to secure a further reduction in gas temperature, and are of greater benefit in those cases operating at high steam pressures. Usually the costs of an economizer in waste heat boiler practice cannot be justified.

The effect of steam pressure on waste heat recovery is shown graphically in Fig. 2, where boiler horsepowers per 1,000 lb. of waste gas are plotted against initial temperatures of gas. The recovery diminishes with increasing steam pressure, due to the reduction in mean temperature difference between gas and steam, and, as a result, the gases leave the boiler at higher exit temperatures. The relation between steam pressure and stack temperature is shown in Fig. 3. Both charts are representative of modern commercial waste heat boiler practice, and Fig. 2 may be used for closely approximating the recovery to be expected from an average installation. Determination of the weight of waste gases required accurate data relative to the rate of fuel consumption, gas analysis, and elements in the charge affecting the products of combustion. The size of the boiler is dependent upon the quantity of gases to be handled, and this, together with the steam working pressure, largely controls the cost of equipment. It is difficult to state, even in a general way, the approximate complete cost of a waste heat boiler installation since the preparation of a suitable site for its erection, alteration to flues, length of gas connections and pipe lines are items which vary with different applications. Within the past two years the lowest cost under observation amounted to $42 per developed boiler horsepower and the highest was $100. Leaving out these two examples, which in one case was an extremely simple and compact arrangement and in the other a most difficult kind of setting, other installations ranged between $68 and $85 per developed horsepower. This is total cost, inclusive of all equipment erected, foundations, flues, housing and piping, and covers equipment designed for 150 lb. steam working pressure.

Although waste heat boilers of the fire-tube type have been installed to operate at steam pressures up to 250 lb., the greater number are in service at 150 lb. or less. The combination of better heat recovery and low initial cost of equipment in an operation at moderate pressure, usually outweighs the benefits to be derived from high pressure steam. When mixed pressure requirements prevail, as is often the case in industrial plants, the low pressure supply may be produced entirely or in part by an available source of waste heat. In any case, the installation should only be made after a thorough study of the conditions of the particular plant, as that is the only way in which a satisfactory result can be assured and the full advantage of the boilers realized.

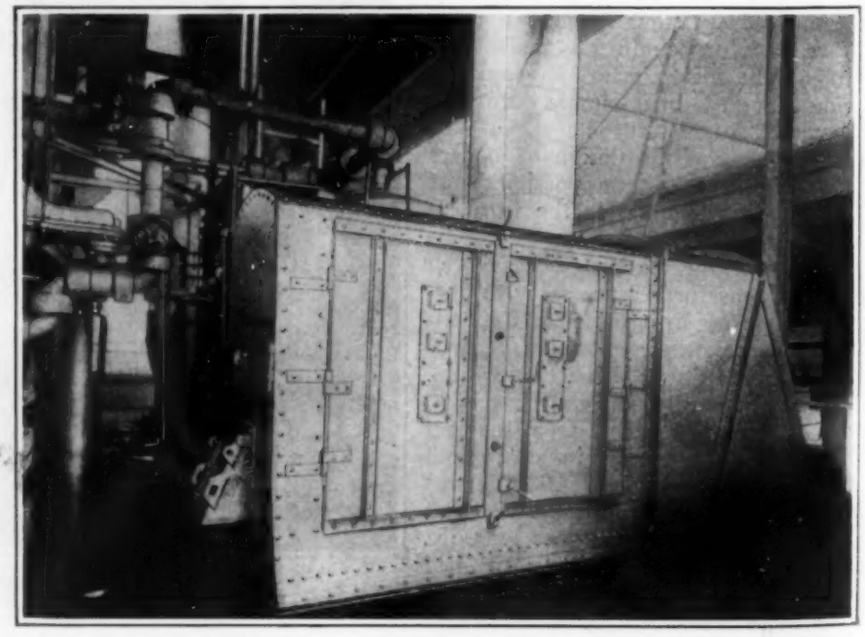


Fig. 6—Gas Duct to Boiler at Same Installation, with Space Provided for Superheater

Application of Superheated Steam in Industrial Processes

By Frank G. Page
Power Specialty Company, New York, N. Y.

COMMERCIAL recognition of the value of superheated steam in this country is less than a generation old, but in spite of that fact no modern steam power plant is constructed without careful study being given to the application of superheated steam. The use of superheat in power generation follows rather similar rules even in widely differing stations so that it has become well understood. In industrial plants, however, with their infinite variety of process requirements, the establishment of precedents is necessarily much slower and more difficult.

There is the further important factor that in many of the industrial plants the men in charge are specialists in some particular line of work other than steam engineering. Such men frequently have to devote all of their time to the development of new products, new processes and means for meeting competition. They are thus prevented from finding an opportunity for the study of detailed means for cost reduction in the generally ignored steam plant. Those executives, fortunate enough to have the opportunity for investigating all angles of their business, and a knowledge of modern developments, have almost without exception found that tremendous gains could be effected through the proper handling of their boiler and engine rooms.

The breadth of application of superheat is commonly misunderstood. For instance, in the manufacture of illuminating gas by the water-gas process, it was formerly assumed that by blowing steam through hot beds of coal everything had been done which could possibly be done to produce the maximum of gas so far as that portion of the process was concerned. Gas having been made for many years before superheat was recognized no excitement was created in the gas industry when it was suggested that if some money should be spent for superheaters, production of gas would be greatly increased and the cost proportionately decreased. Such statements were felt to be exaggerations and largely uninteresting since gas manufacturers were trying to get more out of existing plants rather than spending additional money for new equipment.

When it was found that the use of superheated steam made a tremendous difference through the elimination of water and the increased length of blow in the gas machines the attitude of the water-gas manufacturers was very different. It was later determined in Chicago that where the gas company used high-pressure steam for the generation of power and exhausted it at a slight back pressure into the gas machines a remarkable saving could be produced by superheating the steam sufficiently to carry it through the engines and exhaust it still slightly superheated. This gave a low-pressure steam more nearly at the temperature of the coal and without any entrained water. It saved all of the heat necessary for evaporating the water ordinarily condensed in the engines and kept it for use in the gas making process.

These specific results are cited because they constitute an example of how superheat may be an important factor in process work even though it be such a widely practised and presumably well perfected process, as the manufacture of water gas. The basis upon which superheat may prove to be advantageous in various industrial processes is not difficult to understand but has been largely ignored for the simple reason that many operators, experts in other lines, have never had it called to their attention in a way which would apply specifically to their individual plant.

STEAM is chiefly used as a vehicle for carrying heat. It is more or less valuable, depending upon the amount of usable heat which it can transport. Obviously the heat in the water of condensed steam is not usable in most cases. Thus the only two classes of heat available to the manufacturer are the latent heat used to turn water into steam and the superheat which is added to the steam after it leaves the boiler steam drum. The presence of water is very undesirable in many processing

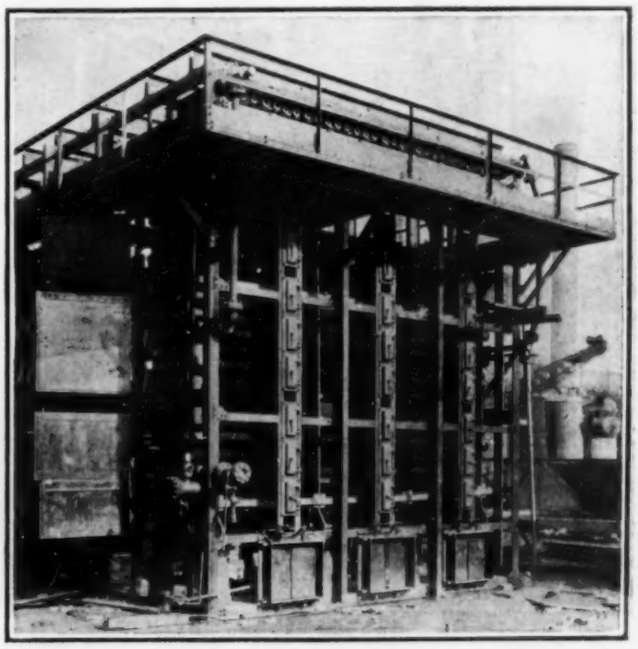


Fig. 1—Crude Oil Still of 3,000 Barrel Capacity Capable of Producing a Final Oil Temperature of 830 deg. F. The Two Lower Rows of Heating Elements are for Superheating Steam to be Used in the Refining Process

operations, as for instance in paper making where the introduction of water into the digesters reduces the strength of the acid solution and increases the amount of time necessary to complete the process. Superheated steam will carry the greatest amount of heat into the kettle with the least amount of dilution after condensing and this has been found of great importance. A regulation of steam temperature can instantly be obtained so that the rate of heat input is controllable.

In many plants there are long steam lines, frequently carrying low-pressure steam, where the drop in pressure is a serious matter and the condensation has to be cared for by steam traps in order to make it possible to use the steam at all. At very low pressures it has been found possible to cut the pressure drop in half in long lines and to eliminate the necessity of steam traps. Steam trap maintenance is costly and superheater maintenance is practically nil.

Numerous plants in the process industries employ large quantities of steam at low pressure and some of these have not yet taken advantage of the fact that by using higher pressure and superheat, steam can be passed through an engine which will act as a pressure reducing valve, exhausting steam at suitable temperatures and pressures for use in process work. This will provide the mill with power costing only the price of heat units taken out in the engine. The cost of these has been shown to be insignificant and effects a great cut in the annual operating expense. Back-pressure turbines have been perfected to work satisfactorily at back pressures formerly considered impossible so that processes requiring high steam pressure can now be served, whereas a few years ago that was impracticable. Fifty or sixty pounds back pressure is by no means unusual.

Superheated steam gives up its heat somewhat more slowly than saturated steam and, therefore, provision has to be made to take care of this in some instances. Assume, for instance, that in a process where numerous jacketed kettles are used, high temperature might be required in the first kettles, and superheated steam blown through them and then into a system of kettles farther on requiring lower temperatures. This would give an extremely efficient use of the steam but the jackets or steam coils used would have to be properly proportioned for the work to be done. It is further understood that the steam bubbles of superheated steam do not collapse as rapidly as those of saturated steam and, therefore, provide better turbulence and agitation where the steam is discharged directly into vats or kettles.

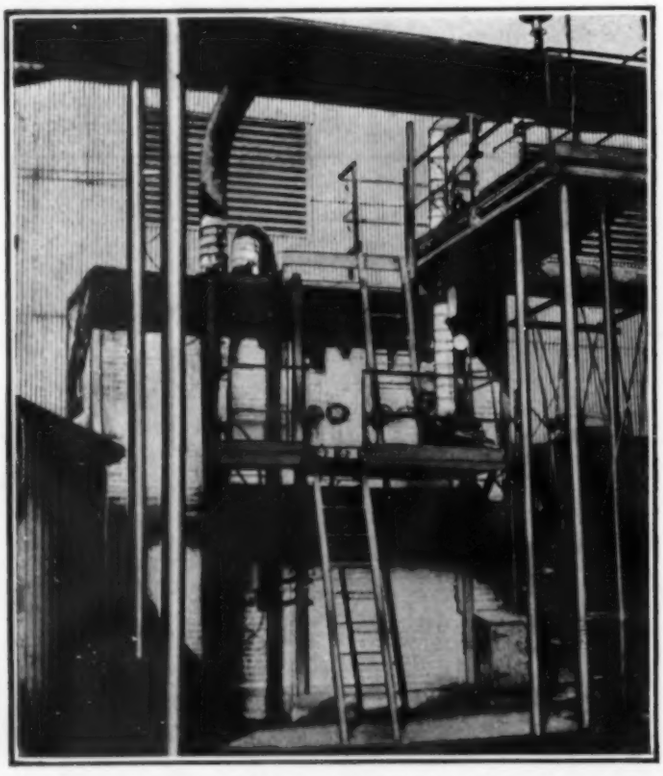


Fig. 2.—Typical Separately Fired Superheater at an Oil Refinery, Superheating Steam at 150 Lb. Pressure to a Final Temperature of About 1250 deg. F., Without Difficulty from Repairs or Other Causes

OIL refiners use large quantities of steam and as they are constantly experimenting and progressing in their manufacturing processes, they early recognized the advantage of using superheat. The refineries, as a rule, have great quantities of waste heat available for heating purposes and it is thus possible to effect important economies by superheating steam with waste heat from the stills and oil heaters. The transmission of superheated steam is so much more efficient than of saturated steam, and oil refineries generally cover such a large ground area, that it is easy for the refiners to save considerable sums annually through superheating steam to be transported about their works. Another important feature is that as the business of the refinery grows, and the requirement for steam increases, the existing steam lines will be able to transport the greater quantity of steam provided it is superheated. Here again saving in steam traps and their maintenance is effected and the annual charge previously made because of steam traps may be credited to the superheaters.

For special work in the heating of either liquids or gases, direct-fired superheaters are employed. These can be made as independent brick-set units or as small-sized portable ones. They are used to produce steam temperatures up to 1,250 deg. F. and the vaporization of liquids has been carried on with final temperature of 1,100 deg. It goes without saying that special provision has to be made for pipe lines in such cases as the loss in strength at these temperatures is considerable.

Contrary to general opinion, the use of superheated steam in heating coils to produce highly concentrated food products at low temperatures has proved a help rather than a detriment. In certain specific cases, it was not infrequent to burn batches of edible products as the point of ultimate concentration was approached and turbulence virtually ceased. The use of superheated steam increased the temperature of the coils sufficiently to carry on generation of steam still further so that steam bubbles were formed, turbulence maintained, and the cook prolonged without burning.

Where damage from the formation of emulsions exists because of the blowing of saturated steam directly into the kettles or vats, superheated steam is usually found to be a satisfactory answer to this problem. The dehydration of some emulsions is so difficult as to be commercially impractical and every effort to avoid such a condition is essential. If the steam is superheated to the proper degree, depending upon the process involved, it will not condense or emulsify the liquid under treatment. This has overcome the difficulties in such process work although it would seem that there are many operators who are still unfamiliar with the practice.

Some Odd Applications of Steam

By Crosby Field
Consulting Engineer, New York, N. Y.

FOR INDIRECT HEATING steam is the cheapest heat supplying medium found in chemical plants, and consequently is usually first considered. Unfortunately, the engineer frequently finds that the temperature range required is above that of the steam available, or that the contemplated installation is too far from his high pressure mains, or any one of a number of other difficulties, which make the supplying of the steam a real problem. A few applications of this type, so infrequently met with as to deserve the term odd, or at least the term unusual, are described below. No cases have been included which are not of a general nature, which will normally be met some time or other in the expansion of chemical plants utilizing indirect heaters.

The cheapest form of steam is, of course, that obtained at the exhaust of pumps, engines, or other heat-to-mechanical energy transformers. As pointed out some years ago [1] it will pay to ascertain from a theoretical viewpoint the most economical back pressure at which the plant should be run, considering the heating operations as well as the mechanical power requirements.

These requirements are obtained from a survey of the actual or proposed plant, which survey naturally divides itself into two parts, the first a study of the mechanical power engines, listing the load of each in hourly or half-hourly periods, and the supply of steam at the various back pressures considered. This part thus considers only the suppliers of exhaust steam. The second part is a study of the steam consuming equipment. A table should be made including the name of the apparatus, its location (building or floor), the pounds consumed per hour, the number of hours run per day, and the probable time schedule. The steam pressure being used should be noted, as well as the possibility of its being changed advantageously to use another pressure, probably lower, as well as other pertinent remarks, such as the pipe size, freedom from oil or contamination, etc.

FOR example, one such survey showed the following:

379 vats consuming steam in open boiling widely varied their requirements, from 110 pounds in 5 minutes for one, to 33,500 pounds in 18 hours for another. The pressure also varied from 5 pounds per square inch to 100; with very slight changes to some they were all made to operate satisfactorily on the final back pressure selected. The total steam consumed in this way each day amounted to 634,000 pounds.

39,000 square feet of room heaters (radiators), requiring 13,000 pounds of steam per hour.

42 pieces of chemical equipment, using steam at 5 pounds per square inch pressure or less and requiring maximum of 10,000 pounds per hour.

80 pieces using from 5 to 10 pounds per square inch requiring maximum of 35,000 pounds per hour.

120 pieces using from 10 to 20 pounds per square inch requiring maximum of 33,000 pounds per hour.

170 pieces using from 20 to 25 pounds per square inch requiring maximum of 32,000 pounds per hour.

537 pieces using from 50 to 100 pounds per square inch requiring maximum of 130,000 pounds per hour; of which 239 could be changed to 25 pounds or lower, with a maximum of 90,000 pounds.

80 pieces using from 100 to 150 pounds per square inch requiring maximum of 15,000 pounds per hour.

12 pieces using from 150 to 250 pounds per square inch requiring maximum of 7,000 pounds per hour.

5 pieces using from 250 to 300 pounds per square inch requiring maximum of 2,000 pounds per hour.

Applying the results of the above survey to the method outlined in the reference, the theoretically proper back pressure was obtained, and the plant operated at that pressure. Further discussion of the method and the results obtained is not within the province of this article, which is to deal with the odd or unusual cases arising from such a survey and the application of the method.

ALMOST interesting series of problems immediately became evident, in that the exhaust steam mains completely eliminated the high pressure mains in many parts of the plant, but in so doing isolated several important pieces of apparatus requiring high pressure steam—from the viewpoint of steam requirements high pressure oases in a veritable desert of low pressure supply mains. Further study showed several other pieces of proposed equipment which would require steam at pressures considerably above the high pressure plant supply, in this case 150 lb. per sq.in. Obviously this apparatus could be supplied by one of several methods, as for example:

(a) Installing separate small power high pressure boilers nearby.
(b) Running special high pressure mains.
(c) Utilizing the lower pressure steam and compressing it by either steam driven or motor driven compressors placed near the source of utilization.

Under the general direction of the author, Dr. Alan E. Flowers and Mr. W. O. Durbin investigated quite thoroughly the general solution of this problem as applied to the general operating conditions at that time (1919-1920) of interest to us, and the results are summarized hereinbelow. Based on this work the author installed several small steam compressors, with every degree of economy and technical success. Since that time the continued development of the multi-stage turbo-compressor has made available a most useful machine for this work, which should always be kept in mind as a possibility

[1] "Exhaust Steam at High Back-Pressures" by Crosby Field, Chem. & Met., Vol. 20, No. 1, Jan. 1, 1919, and "Tests on Small Engines at High Back-Pressures" by Alan E. Flowers, R. J. Pepper and Crosby Field. Chem. & Met., Vol. 22, No. 7, Feb. 18, 1920.

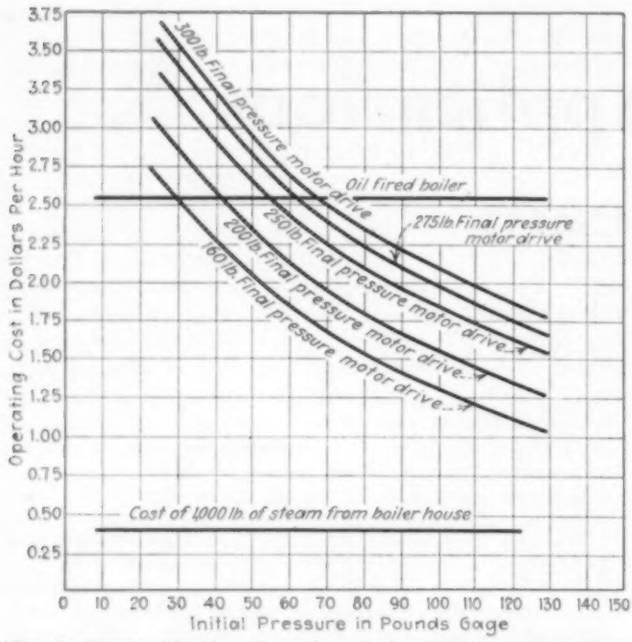

Operating Cost in Dollars Per Hour
Initial Pressure in Pounds Gage
300 lb. Final pressure motor drive
Oil fired boiler
275 lb. Final pressure motor drive
250 lb. Final pressure motor drive
200 lb. Final pressure motor drive
160 lb. Final pressure motor drive
Cost of 1,000 lb. of steam from boiler house

Fig. 1—Curves Showing Operating Costs of Motor-Driven Compressors for Compression of 1,000 lb. of Steam per Hour and for Generation of 1,000 lb. of Steam per Hour with an Oil-Fired Boiler

One recurring case conveniently cured by a small steam compressor is its use for short periods to tide over valleys in the steam pressure curve due to temporary overloading of the mains. This frequently occurs where continued additions of equipment have gradually loaded the mains to the point that the pressure curve has periods of depression, yet the replacement of the mains by longer pipe or supplemental mains is not yet warranted. In this case the compressor, of course, is placed near to the important piece of equipment in which it is necessary to maintain the higher temperature during the period of general pressure depression. Frequently the control can be made automatic, so that the compressor maintains the pressure without any attention.

The average chemical plant slowly but surely accumulates a number of retired vacuum pumps, compressors, pumps, etc., which are not quite good enough to warrant their being left in commission on their regular jobs, and so are sent to the junk heap—sometimes more euphoniously called "spare equipment." Such are of course frequently ideally suited for steam compression.

Although the question of steam compression most frequently arises in connection with the consideration of use of exhaust steam, yet it is by no means limited thereto, but is applicable to many cases where a higher steam pressure is required than is readily available.

The results of the investigation are shown as curves in Figs. 1, 2, 3, and 4. Inasmuch as these apply only to the special conditions of the plants under consideration, and with the cost data applying thereto at that time, a complete set of calculations for two points of the curve are given below, to enable the reader to substitute therein his own special cost data. To quote further the words of Messrs. Flowers and Durbin summarizing their results:

"For a steam supply of 1,000 lb. or less per hour, it is more economical to compress steam from 90 lb. or higher initial pressure to the required final pressure in either a motor- or steam-driven compressor than it is to generate steam at the required final pressure in an oil-fired boiler.

"For a steam supply of 1,000 lb. or less per hour, it is more economical to compress steam in a steam-driven compressor from 60 lb. initial pressure to 242 lb. final pressure than to generate steam in an oil-fired boiler. With final pressures above 242 lb. it is more economical to use a boiler. In a motor-driven compressor the operating cost of the compressor with 60 lb. initial pressure is less than that of a boiler at final pressures below 273 lb. Above 273 lb. final pressure, it is cheaper to use a boiler if the initial pressure is 60 lb. or less.

"For a steam supply of 1,000 lb. or more per hour it is more economical to generate steam in an oil-fired boiler than to compress it from initial pressures of 30 lb. or less to final pressures of 160 lb. or more.

"The amount of steam upon which the calculations are based is 1,000 lb. per hour. The steam is assumed to be saturated at the various initial pressures. The compression is assumed to be adiabatic, the compressor cylinder being lagged but not jacketed.

"In the calculation of the final temperatures of compression, the value of K, or the ratio of the specific heat at constant pressure to the specific heat a constant volume, is taken at 1.31 for high ratios of compression and at 1.30 for low ranges of compression. The final temperatures were checked with the total heat-entropy chart (Mollier diagram). The loss of temperature by radiation was calculated upon an assumed loss of 0.5 B.t.u. per sq.ft. per hour per deg. F. in differences in temperature. The service costs of operating are based upon the present cost of service at the works. The fixed charges are based upon installation costs estimated from known installation costs of similar equipment.

"The operating costs have been plotted in two ways, both against final pressures and against initial pressures. The steam boiler operating costs approximate a horizontal line on both sets of curves. These curves show clearly under what conditions a compressor or a boiler is the more economical.

"The sizes of compressors needed vary from a 6.5 in. diameter x 8 in. stroke to a 10 in. diameter x 10 in. stroke. The type of compressor used in the calculations

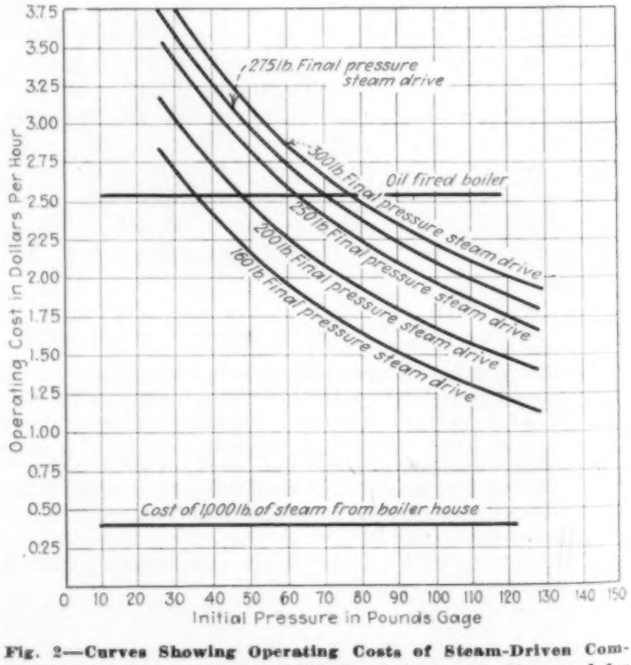

Operating Cost in Dollars Per Hour
Initial Pressure in Pounds Gage
275 lb. Final pressure steam drive
300 lb. Final pressure steam drive
Oil fired boiler
250 lb. Final pressure steam drive
200 lb. Final pressure steam drive
160 lb. Final pressure steam drive
Cost of 1,000 lb. of steam from boiler house

Fig. 2—Curves Showing Operating Costs of Steam-Driven Compressors for Compression of 1,000 lb. of Steam per Hour and for Generation of 1,000 lb. of Steam per Hour with an Oil-Fired Boiler

is single stage, double acting, operating about 215 r.p.m. Standard air compressors, fitted with metallic packing and drain cocks and designed to withstand high pressures would answer the purpose.

"In comparing the operating costs of a compressor with those of a boiler, the fact must not be overlooked that the steam generated in the boiler is saturated and does not contain the superheat that will be obtained by compression.

"The high cost of operating a boiler is due both to the present high cost of fuel oil ($0.13 per gallon) and to the cost of special labor, a second-class fireman being required. The cost of attendance for a compressor is not so high, as a compressor can be operated by the process labor."

A special case that is ideally suited to the centrifugal or turbo type of steam compressor is that of evaporation, particularly where multi-stage evaporation is taking place. At least one large manufacturer is prepared to furnish "steam boosters" (to use their term) for this kind of service. Their recommendations comprise a single stage compressor for 10 to 20 lb. gage, or from 20 to 30 lb. gage for quantities of 1,000 cu.ft. per minute or larger. Based on steam saturated at 10 lb. gage pressure this amounts to about 3,600 lb. per hour.

From this it will be seen that the minimum quantity of steam that can economically be handled is 3,600 lb. per hour for a ratio of compression of about 2. Should this ratio be reduced this minimum would also be reduced, say to about 2,400 lb. per hour.

For ratios of compression greater than 2, then two single-stage compressors in series, or one multi-stage compressor should be used. These units may be provided

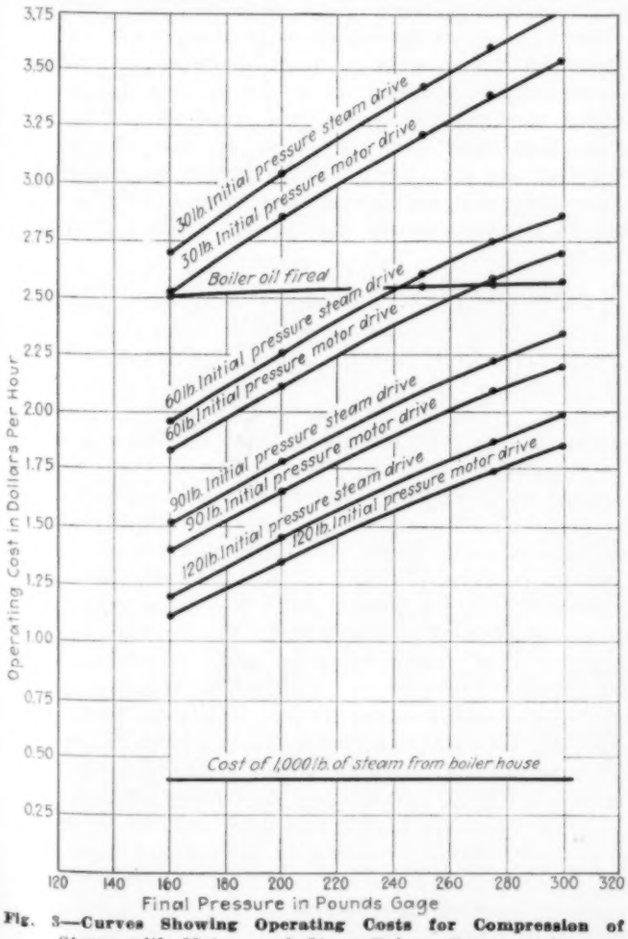


Fig. 3—Curves Showing Operating Costs for Compression of Steam with Motor- and Steam-Driven Compressors

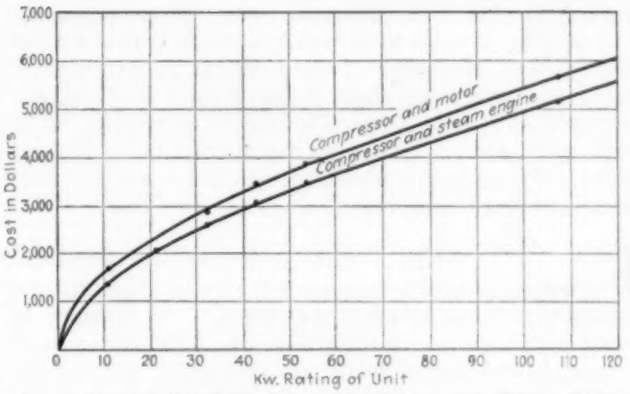


Fig. 4—Curves Showing Costs of Motor- and Steam-Driven Compressors Units

with either motor or turbine drive, and unless the temperature of the steam is so high as to require special modifications, the compressor will be substantially identical with those being installed at present in large numbers for air compression.

One most frequent objection to the use of exhaust steam is the fear that the oil it contains will cut down the heat transfer capacity of coils, jackets or the like. In cases where the steam is condensed in open boiling, the fear that the contained oil will affect the product is even more pronounced. A careful investigation extending over large plants having numerous units showed an average well under 42 parts per million (by weight) before separation, and after passing through separators but before use as steam, less than 10 parts per million.

Oil should be absent from the exhaust of turbines, yet a large number of complaints of "oil" from such exhaust caused an investigation by the author which surprised him greatly. There was never any oil present, but suspended matter carried over from the boilers and collected from the pipes varied from 5 to 100 parts per million. Of course the same percentage was found in the high pressure steam. Incidentally, some of the higher percentages were obtained from plants having the most elaborate and best operated water-treating installations.

Should attempts to use exhaust steam be frustrated by the presence of oil in quantities greatly in excess of the above magnitude, search for other possible sources of contamination. Reciprocating air compressors are great offenders and the use of compressed air for acid lifts, montejus, drying of filter cake, etc., is so common that we rarely think of it as an oil carrier—but let some one try to foist upon us the use of exhaust steam carrying a fraction of this oil, and we rush to protect this attempted violation of the purity of our product.

A final objection to be met and overcome in introducing the use of exhaust steam is of such a nature that my only excuse for mentioning it is its prevalence. It is quite universally believed that exhaust steam has been robbed of the greatest portion of its heat content, and consequently a great excess of it must be used, with consequent enlargement of the reactors or other containers, excess of condensate in open boiling, longer time for reaction, and other detrimental aspects. The only way to overcome this objection is to continually "demonstrate the steam table." Although tiresome, it is yet necessary, once this fear has been expressed. And it is even more necessary in the final installation to see to it that the traps are of ample size and properly located, and that the steam piping is insulated and well laid out, else this objection loses a lot of its silliness, and becomes

quite real, the exhaust steam being of poor quality.

A number of cases have been met which at first seemed to be beyond the range of the available steam temperatures, and which therefore required some more expensive method of heating, such as electric, circulating oil or mercury vapor. Even in such cases a careful study pays, because a combination method frequently results in lower installation cost, and much lower operating cost.

FOR EXAMPLE, a certain process was presented which was stated to require 400 kw. for 36 hours and a maximum temperature of 300 deg. C. All thoughts of using steam vanished at the prospect of 1,500 lb. per sq.in. pressure (allowing a small temperature drop from the heating medium) and yet the 14,400 kw.-hr. per batch loomed up as a heavy operating item, and the estimated cost of installation of 400 kw. of electric contact heaters was considerable.

When the proposed temperature-time curve, that is to say, the curve that would be traced by the recording thermometer, was scrutinized carefully, however, it was found to consist of the following distinct portions:

(a) Heating period, 30° C. to 150° C., 4 hours, 400 kw.
(b) Dissolving period, 150° C., 8 hours, 400 kw.
(c) Heating period, 150° C. to 300° C., 4 hours, 400 kw. to 100 kw.
(d) Reaction period, 300° C., 16 hours, 50 kw.
(e) Cooling period, 300° C. to 160° C., 4 hours, 0 kw.

The reaction further was ascertained to be only slightly endothermic, a considerable part of the 50 kw. being required on account of radiation losses from the reactor.

Seventy-five kilowatts of electric contact heaters were plastered on the outside, and coils placed inside, of the reactor. The latter were connected to a 200 lb. per sq.in. supply of steam, which kept the reactor on schedule through the first heating period, the dissolving period, and the second heating period up to about 230 deg. C. Then the steam was turned off and the 75 kw. electric heaters switched on. The net result was to prolong this second heating up period between two and three hours, but the coils were also used as cooling coils utilizing circulating water, so that the cooling period was cut the amount of the increase in the heating period, leaving the overall cycle time the same. Thus it will be seen 5,600 kw.-hr. or 83 per cent of the power actually consumed was easily transferred from the high cost electricity to lower cost steam, leaving only 1,100 kw.-hr. to be provided by electricity. The cost of electric installation was reduced from that for 400 kw. to 75 kw., with a switching point, of course, for the 50 kw. used throughout the reaction period.

THE READER will note that only 6,700 kw.-hr. out of the total of 14,400 apparently called for at first inspection were actually used. The remainder simply disappeared—were never necessary. This multiplication of maxima is a frequent error in heating calculations, which can be prevented only by a careful integration of the estimated or actual temperature-time charts.

In another case similar to the one just mentioned, introduction of steam coils was prevented by the requirements for internal arrangement of the reactor, including particularly agitator design, and the external surface was all required for electric heaters, pipe connections, etc. The lower temperature heating was accomplished by direct introduction of the steam, the increased water of condensation was taken care of by discovering, several steps preceding in the process, a step where water was added; and this water was cut an amount corresponding to the condensate in the later step.

The examples given are the kind that arise most frequently after the steam system has been installed, and the header pressure established once for all. If the opportunity is afforded to consider the design of a new steam system, then a number could be eliminated by providing for higher steam pressures at the start—which would also provide for higher back pressures on engines and turbines. It has become good and safe practice to operate boiler plants at 250 and 300 lb. per sq.in., and many are operating at still higher pressures. From the viewpoint of the heating medium where coils can be used as the heating element in stills, evaporators and other equipment, the pressure to be carried should be as high as the process temperature of the chemical being processed permits. Generally this pressure is much lower than the economical pressure of generation and transmission of steam when considered from the viewpoint of the steam plant alone. The analogy to an electrical system holds. Steam can preferably be generated at a high pressure (say 300 lb.), transmitted through a pipe line at about that pressure, transformed into mechanical energy to drive the chemical equipment at its location and the exhaust steam at still a comparatively high pressure used to provide the heat for the process. The first cost of a boiler plant and distributing system is greater at high pressures (200 to 300 lb.) than at the more usual 150 lb. pressure, but the operating cost is little, if any, larger. The total heat in steam at 300 lb. is very little greater than at 150 lb., but is at the higher temperature of 421 deg. F. instead of 366 deg. F. The specific volume has been reduced to nearly half; the piping can be smaller and excessive pressure drops permitted for the transmission piping, as the engine or reducing valve near the equipment can be set to maintain the receiving pressure. These savings, however, in so far as first cost is concerned, are frequently more than overshadowed by additional insulation cost. In spite of this, the overall operating cost is no more, and the advantages enumerated above make it an exceptional case when a chemical plant installs a comparatively low pressure boiler plant and system.

AS COMPETITION increases, reduction in manufacturing costs becomes more and more important. Savings can frequently be made in chemical processes by the substitution of a cheaper source of heat for a more expensive one. In numerous cases obstacles appear which at first seem to prohibit this substitution. In this article certain examples have been given of the removal of these seeming obstacles which demonstrate methods believed to be applicable to many cases. These include the use of mechanical compressors to raise the pressure of low pressure or exhaust steam. Charts and calculations are given indicating the general method of determining when steam compression is economical. The results of certain tests for oil and other suspended matter in exhaust steam are stated. There is also included an example of the general case where savings in heat supply can be made by supplying the heat required for a certain cycle in steps, the lower temperature steps being taken care of by low cost steam, the higher temperature steps being provided with the more expensive high temperature heat supply media, such as electricity, circulating oil, or mercury vapor. All of the examples given are not usually considered as standard engineering practice, hence have been called unusual or odd.

READERS' VIEWS AND COMMENTS

An Open Forum

The editors invite discussion of articles and editorials or other topics of interest

Is Cobalt an Impurity in Nickel?

To the Editor of Chem. & Met.:

Sir—I appreciate Mr. McKay's courteous expressions in reply to my recent letter on this subject (see *Chem. & Met.*, vol. 34 No. 7, page 438), but I do not consider that he in any way meets the main argument I put forward, viz., that cobalt is not "practically identical with nickel" and therefore that its inclusion in estimates of the standard of purity of refined nickel is unjustifiable.

Since Mr. McKay referred to research, may I point out the erroneous idea, that cobalt is just another (and more expensive) name for nickel, is a serious hindrance to the true development of both metals. I make this considered statement after some years of experience in the cobalt industry both in refining and development and I am sure it will be supported by all cobalt refiners.

Research workers seeking new fields in alloy metallurgy hear the statement, "cobalt is identical with nickel" and in the main leave it alone. Fortunately every now and then some original thinkers refuse to accept the statement and we get valuable new engineering materials as, e.g., cobalt-cutting steels and the really extraordinary cobalt magnet steels developed recently by Japanese and European metallurgists.

The very curious argument is advanced by Mr. McKay that since both nickel or cobalt when added to iron increase the mechanical strength of iron they may be regarded as "practically identical." But surely many other elements *inter alia* carbon, silicon, tungsten, chromium, molybdenum all increase the strength of iron yet no one seriously argues that these elements are "identical" or even closely similar.

The work of Guillet has shown conclusively that there is no real resemblance between nickel and cobalt steels, and since the greater proportion of refined nickel consumed in industry goes into nickel steel, I submit that no further instance of "practical significance" is necessary. Since, however, Mr. McKay presses me for such instances, I turn to the second largest field for the consumption of nickel, i.e. the nickel-copper alloys and the nickel-copper-zinc alloys known as nickel silvers. Thermal, microscopic and other data now available in literature illustrate clearly the fundamental differences between the nickel-copper and the cobalt-copper series and I need not trespass on your space in detailing these, but it is perhaps not so well known as it should be that there are other striking differences that constitutional diagrams do not reveal.

No small part of the popularity of the nickel-copper alloys is due to their appearance, that is to say their *silvery whiteness of color*. This very valuable property (from a commercial standpoint) is *entirely due to nickel*. The decolorising property of nickel on the colored elementary metals, copper and gold, is almost unique. On copper it begins with relatively small additions and at only about 15 per cent of nickel content, the characteristic salmon-pink color of copper entirely disappears, and beyond this point we get a whole series of white alloys. The effect of cobalt, on the other hand, is entirely different. So far from decolorising copper, the addition of cobalt even up to 50 per cent makes no appreciable alteration. This fact is important in the nickel-silver industry. As many workers have shown, the color of nickel silver, i.e. the nickel-copper-zinc alloys, is almost entirely due to nickel and increases in whiteness in direct ratio to nickel content. Zinc, although itself a white metal, has little effect within commercial limits. At certain stages-particularly in the lower grades differences of as small as one per cent of nickel can be distinguished by color. But cobalt again has no effect on this property; it simply dilutes the action of nickel, and in this sense must be considered a deleterious impurity.

The foregoing facts prove conclusively that in an overwhelming proportion of the uses of nickel in industry it is not replacable by cobalt—nor indeed does nickel replace cobalt. In all assays therefore, the two elements should be shown separately and distinctly.

I not only repeat that this is a question of metallurgical ethics, but also stress the "practical significance" that Mr. McKay deprecates. It is the consumer's point of view that should be considered. If consumer "A" buys nickel containing anything from one-half to one per cent of cobalt, he is clearly not on an equality in competition with "B" who buys on an assay exclusive of cobalt—whether he uses his nickel in ferrous or non-ferrous alloys.

That relatively small percentages are involved does not in the least affect the principle at stake and if cobalt is to be included in descriptions of refined nickel any tolerance can be allowed logically and proportions as high as two or even three per cent included. Would Mr. McKay advocate this? W. R. BARCLAY.

American Mond Nickel Company,
Clearfield, Pa.

* * * *

Cresylic Acid and the Flexible Tariff

To the Editor of Chem. & Met.:

Sir—All you say in your editorial on the cresylic-acid tariff is perfectly true. The real answer to this problem is the marketing of associated products, particularly pitch. But for a technical journal of the standing of *Chem. & Met.* to attempt to put the public straight and then make the inaccurate statement, viz.: "This is the first instance in which the discretionary powers of the so-called flexible tariff law have been used for *reducing* an existing duty * * * " is inexcusable. Have you guardians of the public welfare so quickly forgotten that quail on toast can now be purchased cheaper thanks to the President's reduction in the duty on live bob-white quail and that the farmer is growing prosperous again because of the reduction in the duty on mill feeds? Surely we must give the flexible tariff its due. CHEMICO TARIFF.

New York, N. Y.

PATENTS ISSUED
Aug. 9 to Aug. 30, 1927

PAPER, PULP AND SUGAR

Method of Dry Distillation of Alkalized Waste Liquor from the Soda Cellulose Manufacture. Erik Ludvig Rinman, Djursholm, Sweden.—1,638,061.

Method of Bleaching Wood Pulp. Frederick G. Sherbondy, Akron, Ohio, and Max E. Boehm, Appleton, Wis.—1,638,886.

Means for Eliminating Water from the Pulp on the Wire of Paper-Making Machines. Victor Antoine, Lambermont, near Ensival, Belgium.—1,638,975.

Process of Elaborating Corn Stalks Into Pulp for Use in Paper Making and the Like. Orland Russell Sweeney, Ames, Iowa. —1,639,152.

Sugar-Mill Machinery. John E. Stuntz, Central Estrella, Cuba, assignor to The Hooven, Owens, Rentschler Company, Hamilton, Ohio.—1,640,059.

Process for the Recovery of Pulp from Printed Waste Paper. Ernest Theodore McGregor, Vancouver, British Columbia, Canada.—1,640,612.

RUBBER AND SYNTHETIC PLASTICS

Rubber Composition. Roy H. Uhlinger, Mount Lebanon Township, Allegheny County, Pa., assignor to Thermatomic Carbon Company, Pittsburgh, Pa.—1,638,421.

Method and Apparatus for Making Hollow Rubber Articles. John R. Gammeter, Akron, Ohio, assignor to The B. F. Goodrich Company, New York, N. Y.—1,639,430.

Process for Preparing Rubber-Containing Plastics and Products Obtained Thereby. John McGavack, Elmhurst, N. Y., assignor to The Revere Rubber Company, Chelsea, Mass.—1,640,363.

Process for Preparing Rubber-Containing Plastics and Products Obtained Thereby. John McGavack, Jackson Heights, N. Y., assignor to Revere Rubber Company, Chelsea, Mass.—1,640,364.

Art of Making Reclaimed Rubber. Charles H. Campbell, Pittsburg, Pa., assignor to American Glue Company, Boston, Mass.—1,640,817

Process of Mixing a Soluble Filler with Rubber. Charles H. Campbell, Pittsburgh, Pa., assignor to American Glue Company, Boston, Mass.—1,640,818.

PETROLEUM REFINING

Method of Treating Hydrocarbons. Alexander B. Way, Lynn, Mass., assignor to Lewis A. Way, Pittsburgh, Pa.—1,638,021.

Material for the Treatment of Hydrocarbons. Alexander B. Way, Lynn, Mass., assignor to Lewis A. Way, Pittsburgh, Pa. —1,638,022.

Process for Cracking Oil. Gustav Egloff, Independence, Kans., assignor to Universal Oil Products Company, Chicago, Ill. —1,638,093.

Process of Treating Hydrocarbons. Carbon P. Dubbs, Wilmette, Ill., assignor to Universal Oil Products Company, Chicago, Ill.—1,638,112.

Process for Cracking Oils. Carbon P. Dubbs, Wilmette, Ill., assignor to Universal Oil Products Company, Chicago, Ill. —1,638,113.

Process of and Apparatus for Cracking Oil. Gustav Egloff, Chicago, Ill., assignor to Universal Oil Products Company, Chicago, Ill.—1,638,115.

Apparatus for Cracking Hydrocarbons. Gustav Egloff and Joseph C. Alther, Chicago, Ill., assignors to Universal Oil Products Company, Chicago, Ill.—1,638,116.

Process of Preparing An Adsorbent for Oils. Wirt D. Rial and Earle W. Gard, Wilmington, Calif.—1,639,274.

Method of Hydrocarbon Oil Conversion. Lyman C. Huff, Chicago, Ill., assignor to Universal Oil Products Company, Chicago, Ill.—1,638,735.

Process of Dehydrating Oils. Sidney Born and Howard Edgar Bonnette, Bartlesville, Okla., and John Charles Walker, Eldorado, Kans., assignors to Empire Gasoline Company, Dover, Del.—1,639,325.

Apparatus for Distilling Oil. John W. Coast, Jr., Tulsa, Okla., assignor, by mesne assignments, to Doherty Research Company, New York, N. Y.—1,639,327.

Refining of Hydrocarbon Oils. Ernest B. Phillips, East Chicago, and James G. Stafford, Whiting, Ind., assignors to Sinclair Refining Company, Chicago, Ill.—1,639,531.

Process of Purifying Petroleum Products. Samuel J. Dickey and Raymond C. Wheeler, Los Angeles, Calif., assignors to General Petroleum Corporation of California. —1,639,988.

Process of Treating Heavy Hydrocarbons. Arthur D. Smith and John Perl, Arkansas City, Kans.—1,640,223.

Process and Apparatus for Cracking Hydrocarbon Oils. Warren F. Faragher and William Arthur Gruse, Pittsburgh, Pa., assignors to Gulf Refining Company, Pittsburgh, Pa.—1,640,444.

Process of Purifying Hydrocarbons. Leon W. Parsons, Cambridge, Mass., and Stewart P. Coleman, Corpus Christi, Tex., assignors to Standard Development Company, New York, N. Y.—1,640,720.

Absorption Plant. Carl F. Braun, Pasadena, Calif.—1,640,747.

Art of Distilling Oils. Frank A. Howard and Nathaniel E. Loomis, Elizabeth, N. J., assignors to Standard Development Company.—1,640,938.

COAL PROCESSING

Carbonizing Apparatus. George W. Wallace, San Francisco, Calif.—1,639,390.

Process of Distilling and Gasifying Solid Carbonaceous Fuel. George W. Wallace, San Francisco, Calif.—1,639,391.

Method of Carbonizing Fuel. George W. Wallace, San Francisco, Calif.—1,639,417.

ORGANIC PROCESSES

Process of Reducing Viscosity of Nitrocellulose Solutions and Product Thereof. Earle C. Pitman, Parlin, N. J., assignor to E. I. du Pont de Nemours & Company, Wilmington, Del.—1,636,319.

Process of Producing Explosives. Frank H. Bergeim, Woodbury, N. J., assignor to E. I. du Pont de Nemours & Company, Wilmington, Del.—1,637,726.

Manufacture of Alkyl Carbonates. Harry Gilbert Mitchell, Baltimore, Md., assignor to U. S. Industrial Alcohol Co.—1,638,014.

Lithium Salt of 2-Phenylquinoline-4-Carboxylic Acid and Process of Making the Same. Moses L. Crossley, Boundbrook, and Maurice L. Dolt, Somerville, N. J., assignors to The Calco Chemical Company, Boundbrook, N. J.—1,638,832.

Mercury Salt of 2-Phenylquinoline-4-Carboxylic Acid and Process of Producing the Same. Moses L. Crossley, Boundbrook, and Maurice L. Dolt, Somerville, N. J., assignors to The Calco Chemical Company, Boundbrook, N. J.—1,638,833.

Iron Salt of 2-Phenylquinoline-4-Carboxylic Acid and Process of Making the Same. Moses L. Crossley, Boundbrook, and Maurice L. Dolt, Somerville, N. J., assignors to The Calco Chemical Company, Boundbrook, N. J.—1,638,834.

Treatment of Liquids Containing Oil or Fatty Substances and the Like. John Avery, Armadale, Australia, assignor to Australian Lanoline Proprietary, Limited, Melbourne, Victoria, Australia.—1,638,977.

Catalytic Reduction of Organic Nitro Compounds. Myrtil Kahn, Cologne, and Rudolf Mayer, Leverkusen, near Cologne-on-the-Rhine, Germany, assignors to Grasselli Dyestuff Corporation, New York, N. Y. —1,639,186.

Process of Making Activated Carbon. George W. Wallace, San Francisco, Calif. —1,639,356.

Process for the Manufacture of Diarylguanidines. Cecil John Turrell Cronshaw and William Johnson Smith Naunton, Manchester, England, assignors to British Dyestuffs Corporation Limited, Manchester, England.—1,639,724.

Process for the Manufacture of Diarylguanidines. Cecil John Turrell Cronshaw and William Johnson Smith Naunton, Manchester, England, assignors to British Dyestuffs Corporation Limited, Manchester, England.—1,639,725.

Process of Preparing Vat-Dyestuff Derivatives from Vat Dyestuffs and Alkyl Esters of Monochloracetic Acid. Birkett Wylam. Lancaster, John Edmund Guy Harris, Carlisle, England, and John Thomas, Grangemouth, Scotland, assignors to Scottish Dyes, Limited, Grangemouth, Scotland. —1,640,018.

Antispasmodic. Friedrich Leuchs, Elberfeld, Germany, assignor to Winthrop Chemical Company, Inc., New York, N. Y.—1,640,506.

INORGANIC PROCESSES

Process for the Direct Synthesis of Ammonia. Forrest C. Reed, Easton, Pa.—1,639,272.

Production of Activated Nitrogen and of Oxides of Nitrogen Therefrom. William Arthur Bone, St. Albans, England. —1,639,584.

Manufacture of Fertilizers. Carl Bosch, Ludwigshafen-on-the-Rhine, Germany, assignor, by mesne assignments, to I. G. Farbenindustrie Aktiengesellschaft, Frankfort-on-the-Main, Germany.—1,639,585.

Recovery of Copper, Zinc and Other Metals from Solutions Containing Chlorides and Sulphates. Karl Mattenklodt and Hans Schramm, Duisburg, Germany, assignors to Duisburger-Kupferhutte, Duisburg, Germany.—1,639,610.

Process of Manufacture of Alkali-Metal Sulphides. Horace Freeman, Vancouver, British Columbia, Canada, assignor of one-half to Canada Carbide Company, Limited, Montreal, Canada.—1,640,314.

Process of Manufacture of Alkali-Metal Sulphides. Horace Freeman, Shawinigan Falls, Quebec, Canada, assignor of one-half to Canada Carbide Company, Limited, Montreal, Canada.—1,640,315.

Blast-Furnace Method. Frank W. Davis, Milford, Del., assignor to Samuel G. Allen, trustee.—1,640,485.

Refining Lead. Philip W. Davis, Cambridge, Mass.—1,640,486.

Refining Lead. Philip W. Davis, Cambridge, Mass.—1,640,487.

Process for the Manufacture of Pure Barium Carbonate. Ferdinand Falco, Haspe, Germany.—1,640,652.

CHEMICAL ENGINEERING EQUIPMENT AND PROCESSES

Treatment of Residual Liquors. Linn Bradley, Montclair, N. J., and Edward P. McKeefe, New York, N. Y., assignors to Bradley-McKeefe Corporation, New York, N. Y.—1,637,515.

Rotary Retort. Bernhard Young, Frankfort-on-the-Main, Germany.—1,636,270.

Process of Producing Metallic Carbon. Conway Robinson, Baltimore, Md., assignor to Westinghouse Electric & Manufacturing Company, New York, N. Y.—1,637,052.

Process for the Manufacture of Sponge Iron. Phillip William Nevill, Perth, Western Australia, Australia.—1,635,950.

Rotary-Drum-Filtering Apparatus. Leon Hertenbein, Levallois-Perret, France.—1,636,739.

Hygrometer, Humidity Regulation, and the Like. Albert J. Loepsinger, Providence, R. I., assignor to General Fire Extinguisher Company, Providence, R. I.—1,636,374.

Means for Separating Water and Other Impurities from Mineral or Other Oils or Liquids. Hastings John Holford, Addiscombe, England, assignor of one-half to Percy Portway Harvey, London, England. —1,635,845.

Rotary Pump with Liner Plate. Perry I. Nagle, Chicago Heights, Ill., assignor to American Manganese Steel Company, Chicago, Ill.—1,638,055.

Chemical Mixing and Feeding Apparatus. Walter H. Green, Chicago, Ill., assignor to General Zeolite Company, Chicago, Ill.—1,638,119.

Gyratory Pump or Compressor. Frans Ivar L. Byliger, South Portland, Me.—1,638,183.

Continuous Battery Oil Filter. Henry A. Hills, Grand Rapids, Mich.—1,638,201.

Continuous Weighing Apparatus. Alfred F. Cooke, Pittsburgh, Pa., assignor to Schaffer Poidometer Company, Pittsburgh, Pa.—1,638,244.

Process of Reacting Metals with Gases. Hector Russell Carveth, Niagara Falls, N. Y., assignor to The Roessler & Hasslacher Chemical Company, New York, N. Y.—1,638,471.

Combined Temperature and Pressure Regulator. Frank C. Reeder, Knoxville, Tenn., assignor, by mesne assignments, to The Fulton Syphon Company, Knoxville, Tenn.—1,638,596.

Liquid and Gas Contact Apparatus. Frederick H. Wagner, Baltimore, Md., assignor to The Bartlett Hayward Company, Baltimore, Md.—1,638,670.

Evaporator. Ira Merlis, New York, N. Y., assignor to Kelvin Engineering Co., Inc., New York, N. Y.—1,638,697.

Carbon - Black - Producing Apparatus. Clyde A. Barbour, Jr., Monroe, La.—1,638,722.

Sulphur Burner. Lowry Gillett, Syossett, N. Y., assignor to General Chemical Company, New York, N. Y.—1,638,992.

NEWS *of the* Industry

Chemical Exposition Attracts Wide Range of Exhibits

Technical Sessions, Students Course, and Annual Banquet are Included in Activities of the Week

PREPARATIONS have been practically completed for the opening of the Eleventh Exposition of Chemical Industries which will be held at Grand Central Palace, New York, during the week beginning September 26. Because of the rapid growth in the chemical industry in the last two years, unusual interest attaches to the coming exposition. This is evidenced by the large number of exhibitors who have taken space and by the diversified line of products which will be on display. While the majority of exhibits will come from this country, Canada and other foreign countries also will be represented. Coincident with the exposition will be held the meetings of the Technical Association of the Pulp and Paper Industry. The students course in chemistry and chemical engineering which has been identified with expositions in past years, has again been given a prominent place in the week's activities. The annual banquet of the chemical industries is scheduled for Wednesday evening, Sept. 28.

Following its custom in previous exposition years, *Chem. & Met.* will publish and have available for distribution at the exposition, a detailed program and a list of exhibitors.

APPROXIMATELY 350 companies have arranged to exhibit their goods at the exposition and there will be on display almost everything in the range of chemicals, chemical products, equipment, and raw materials used in chemical manufacture. Special sections have been instituted to permit of distinctive groupings. The section of chemical and chemical product exhibits is three times as large as it was five years ago and machinery exhibits also have increased greatly in number and variety. Other sections are given over to laboratory supplies and equipment; containers, packaging, labeling, and shipping; plastic compositions; and transportation and material handling.

There will be numerous educational exhibits; one of these will be of outstanding importance to the industries and arts using benzol. That is the exhibit of the National Safety Council which will present in completed form the recently concluded and exhaustive study of the toxicity of this solvent when used in products designed for manufacturing and domestic use.

Six bureaus of the Department of Commerce will join in the exhibit to be presented at the chemical exposition. Heretofore this exhibit has depicted only the activities of the Chemical Division of the Bureau of Foreign and Domestic Commerce. This year the Bureau of Mines, Bureau of Standards, the Patent Office, the Bureau of the Census and the Bureau of Fisheries will join with Foreign and Domestic Commerce in the presentation of a joint exhibit showing wherein each of these bureaus can serve the chemical industry. A brochure has been printed which will set forth in detail the services which these bureaus are in a position to perform. For instance, the Bureau of Fisheries was the pioneer in the development of the artificial pearl industry It also devised a chemical processing of fish nets which greatly prolongs their period of use.

One of the major subdivisions of the Bureau of Mines is devoted largely to what may be described as belonging to chemical activities. Chemical work forms a large part of the activities of the Bureau of Standards. Thus through many of the other bureaus there is work which has an important interest to chemists. This will be brought out both graphically and in the printed matter which will be distributed at the exposition.

Annual Banquet of The Chemical Industries

The Fifth Chemical Industries Banquet will be held at the Roosevelt on Wednesday evening, Sept. 28. It will be under the auspices of the Salesmen's Association of the American Chemical Industry, sponsored by American Ceramic Society, American Chemical Society, American Electrochemical Society, Chemical Warfare Association, Chemists' Club, Pressed Gas Manufacturers Association, Chlorine Institute, American Institute of Chemical Engineers, American Leather Chemists Association, Manufacturing Chemists Association, Societe de Chemie Ind., Society of Chemical Industry, American Society for Testing Materials, American Association of Textile Chemists and Colorists, Synthetic Organic Chemical Manufacturers Association and Technical Association of the Pulp and Paper Industry.

Ralph E. Dorland is chairman of the banquet committee. Among the distinguished speakers will be Nicholas Longworth and John W. Davis. John E. Teeple will preside as toastmaster.

THE TECHNICAL Association of the Pulp and Paper Industry will meet on Wednesday afternoon, Sept. 28, in the conference room at the exposition. The program will comprise a series of ten minute addresses and will be under the chairmanship of Elmer C. Tucker, president of the association. The subjects to be discussed and the speakers are as follows: Pulp Washers and Stock Savers, R. C. Campbell, Chas. Fuhrmeister, Jr., and A. H. Vallez; Hydrogen Ion Control in Pulp and Paper Mills, W. A. Taylor; Evaporation in Chemical Pulp Mills, H. Austin; Chromium Plating in the Paper Industry, Hugh D. McLeese; Dorr Equipment in Pulp and Paper Mills, A. Anable; Smelting Furnace Lining, Mr. Bryant; Daylight Illumination for Laboratories and Mills and Displays, Walter N. Polakov; Microscopical Examination of Pulp and Paper L. C. Foster; Continuous Centrifugal for Pulp and Paper, W. C. Laughlin; Minerals for Paper Use, C. M. Redfern.

IN CONNECTION with the exposition there will be given the annual students course on the fundamentals of chemical engineering and industrial chemical practice. The students will be welcomed on Monday afternoon, Sept. 26, by Charles F. Roth, manager of the exposition and also will be addressed by T. B. Wagner, president of the Chemists Club. Prof. W. T. Read, who is chairman of the student course, will then outline the program to be followed throughout the week. The morning sessions will be devoted to general lectures on topics touching on industrial chemical practice. The lecturers will include Arthur D. Little, H. C. Parmelee, F. C. Whitmore, Williams Haynes, Edwin E. Judd, H. E. Howe, and G. Edwin White. The afternoon sessions will be given over largely to technical addresses and discussions. Topics will include such fundamentals of chemical engineering as disintegration, mechanical separation, handling of materials, and a study of raw materials. Speakers will include Chas. E. Locke, S. B. Kanowitz, Arthur Wright, E. J. Sweetland, A. Anable, Arthur W. Hixson, Harlowe Hardinge, P. E. Landolt, A. E. Marshall, Wm. B. Spooner, W. A. McAdams, G. W. O'Keefe, J. H. Nair, Ross C. Purdy, W. S. Calcott, and P. V. Faragher.

Technical Sessions Feature A.C.S. Meeting

APPROXIMATELY 1,500 members and guests of the American Chemical Society participated in the meeting in Detroit September 5-9. The council voted that the society decline to participate in a project to found in Paris an institution for world "control of chemistry." It also voted to hold its September, 1929 meeting in Minneapolis. Previously action had been taken fixing meeting places for 1928 at St. Louis and Swampscott, Mass., and Columbus for the spring of 1929.

The 19 technical divisions of the society held sessions in Detroit. Special interest was aroused by the sessions of the petroleum and industrial divisions which held a symposium on "Chemistry's Contribution to Automotive Transportation." T. A. Boyd, chairman for these meetings, emphasized the coordinate importance of design and materials in automotive development; but he also expressed the opinion that design has become dependent on materials available, thus increasing the importance of development of the best possible materials.

METALLURGICAL contributions to the industry, discussed by John A. Mathews, have not been limited to furnishing of alloy steels, specially heat-treated alloys, and metallic parts; the use of high-speed tools, the result of highly specialized research has been equally important in speeding up mechanical operations and in lowering costs. Similarly with non-ferrous metals, heat-treating technic on parts has been possible only because suitable electrical resistor materials have been available, as explained by H. W. Gillett.

The value of aluminum alloys and of electroplating advances were reported by F. C. Frary and William Blum. The latter emphasized that the electroplating chemist owed much to the automotive industry for its stimulus of research in all kinds of plating, its demands for more scientific and dependable performance in the plating plant, and its encouragement of the whole industry by extensive use of plated parts.

Plate glass output in the U. S. increased between 1905 and 1925 from about 30 to 120 million square feet per year and, according to E. Ward Tillotson, 80 million of the increase is used in automobiles.

William C. Geer, discussing the rubber developments interlocked with automotive advance, laid emphasis on reclaimed rubber as a stabilizer of production and consumption irregularities, and forecast a bright future for this material as a preventive of any serious rubber shortage.

Coated textiles of rubber, pyroxylin, and linseed oil types were discussed by Hamilton Bradshaw and their uses for special service rather than as "substitutes" for natural products emphasized. Leather chemistry in this industry was discussed by Norman Hertz and automobile finishes by H. C. Mougey. The latter presented the problem of speed and method of application as well as of character and durability of the finish.

THE ELECTRICAL uses of synthetic resins are numerous and well recognized by the automotive industry, according to A. V. H. Mory; but mechanical uses even for large or vital structural parts are relatively new.

The natural constituents of cracked gasolines of high anti-knock property were reported by J. Bennett Hill as one of chemical industry's latest and most important contributions to the motor fuel problem.

In the field of lubricants there has been joint effort of scientist, engineer, and plant operator for stock selection, process development and control, product testing, and now in fundamental study of the question, "what is lubrication." L. W. Parsons in review of this field emphasized the constantly changing conditions; among other examples he cited the ambition of the refinery man to develop such technic in his plant as ultimately to make unnecessary the use of a sulphuric acid treatment of the lubricating oils.

New Regulations for Trading in Alcohol

NEW REGULATIONS governing the manufacture, distribution and consumption of industrial alcohol will be issued soon by the Prohibition Bureau, final copy having been sent to the Government Printing Office. The new regulations are designed to facilitate the legitimate production and use of industrial alcohol while at the same time closing loopholes which have made possible diversions of the liquid to the illicit liquor trade. Known as Regulation No. 3, the new order will embody all of the clauses of old Regulation No. 61 which have been found worthy of retention, together with the changes and additions made by officials of the Prohibition Bureau. Conferences were held with representatives of the industries concerned before the regulations were approved and all suggestions have been given full consideration, it is said at the Bureau.

Dr. Knight Appointed Chief of Chemistry Bureau

Dr. Henry G. Knight, dean of the college of agriculture and director of the experiment station of the University of West Virginia, has been appointed chief of the new Bureau of Chemistry and Soils of the United States Department of Agriculture. The new Bureau of Chemistry and Soils which Doctor Knight is to direct combines three important research fields in the department—chemistry, soils, and fixed nitrogen—formerly represented by the old Bureau of Chemistry, the Bureau of Soils, and the Fixed Nitrogen Research Laboratory.

Electrochemists on Trip Across Continent

THE AMERICAN Electrochemical Society is en route to the Northwest. About 50 members left Chicago September 4 and traveled to Minneapolis for their first stop. At the University of Minnesota they were taken in charge by Dr. Charles A. Mann. A sightseeing trip about the city was followed by an inspection of the University campus, the ore testing laboratory and the chemistry building. At the technical session at the University, I. J. Moltkehansen presented an interesting paper on the electrochemical and electrometallurgical industries of Norway. Many mistakes had been made and much money spent unwisely in these developments which could have been avoided by more careful investigation of the commercial and technical aspects of the projects. Despite this Norway in 1926 exported over 50 products aggregating 360,000 tons and valued at over 200,000,000 kronen. Norway now has 2,000,000 hydro-electrical hp. and 800,000 hp. of this is used in electrochemical and electrometallurgical industries. The chief industries are aluminum, nitrogen fixation, carbides and animal oil products. Eric A. Lof discussed the paper and stated the arc process of nitrogen fixation was now uneconomical because of the cost of power and added that a new plant was now being built to fix nitrogen which used about 2 hp. per ton of product as compared to 12 hp. per ton used in the arc process. He said hydro power could not be bought for under $15 per hp. year.

A SPLENDID paper on the electrodeposition of rubber was presented by S. E. Sheppard. This process uses natural or prepared rubber latex wherein the negatively charged rubber particles are subjected to an electric field to form anode deposits. The method was described in *Chem. & Met.* in June, 1926, page 358.

A third paper by J. Slepian dealt with thin film rectifiers. These rectifiers are based on the emission of charged particles from metal under the influence of an electric field. If normal insulating material of high dielectric strength is placed near the metal it is possible at normal temperatures to get unidirectional conduction.

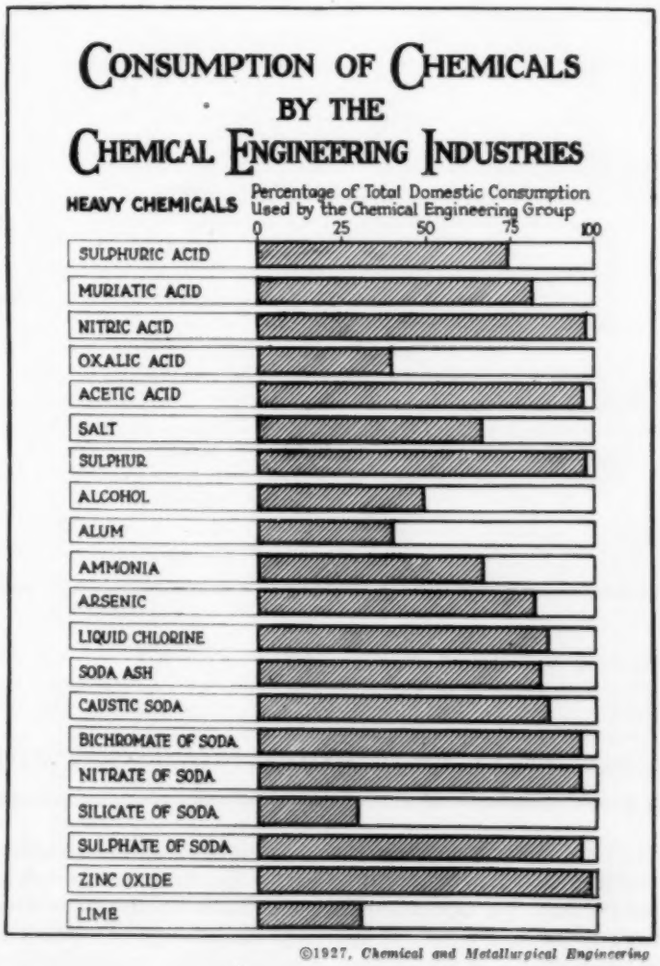
A final paper on the program was presented by S. C. Lind and George Glockler. In former researches Dr. Fink had used radon emanations to cause condensation from ethane and other gases. In this paper it was attempted to secure the same results by use of silent electric discharges. By ingenious experimentation condensation was secured and the authors were led to believe the results checked very closely with the experiments with radon ionization. Following the technical meeting a dinner and dance were held and the augmented party left that evening with Butte and Anaconda as next stopping points.

A Concentrated Industrial Market for Heavy Chemicals

Chemical engineering industries are shown to account for three-fourths of the total domestic consumption

A Chem. & Met. Market Survey

AMONG industries the chemical engineering or process group is unique in the degree to which it is self contained. Few other industries or groups of industries hold the unusual advantage of being both producers and consumers of their own products. This close inter-relation has resulted in the development of a concentrated market within the group that accounts for at least three-fourths of the total domestic consumption of heavy chemicals. The remaining fourth of this total is spread among an extremely wide range of industries and in a comparatively few instances, such as salt, ammonia, and soda, a limited proportion is sold to the ultimate individual consumer. By and large, however, heavy chemicals are raw materials bought and sold in the industrial market.



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The paucity of accurate statistics on the consumption and distribution of chemicals makes it practically impossible to obtain exact figures on the quantities used in the various industries. A fairly close approximation can be made, however, by the use of market data accumulated by *Chem. & Met.* and published each year in the Annual Review and Statistical Numbers. Information obtained from producers and consumers forms the basis of a series of quantitative distribution studies that have included practically all of the more important heavy chemicals. Using these distribution data in conjunction with the most recent Census statistics (1925) of production it has been possible to obtain, for the first time, a comprehensive picture of the extent and character of the market offered by the chemical engineering industries. These figures, frankly presented here as the most reliable estimates now available, are given in detail in the table on the following pages and have been summarized in the accompanying chart.

The chemical engineering group is made up of the industries that produce the following products: Heavy chemicals, fine chemicals, electrochemicals, coal byproducts, dyes and coal-tar products, fertilizers and insecticides, petroleum, textiles and rayon, leather, pulp and paper, rubber, soap, sugar, wood chemicals, food products, paint and varnish, explosives, oils and fats, glue and gelatin and glass and ceramics. It will be noted that this group of industries accounts for approximately 75 per cent of the total domestic consumption of the following twenty important heavy chemicals: Sulphuric acid, hydrochloric acid, nitric acid, acetic acid, oxalic acid, salt, sulphur, alcohol, alum, ammonia, arsenic, liquid chlorine, soda ash, caustic soda, bichromate of soda, nitrate of soda, silicate of soda, sulphate of soda, zinc oxide and lime. The percentage consumed by the chemical engineering group varies from 29.8 per cent in the case of sodium silicate, which is largely used as an adhesive in the fiber board, furniture and paper-box industries, to 98.3 per cent in the case of zinc oxide, the use of which is concentrated in the rubber, pigment,

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Estimated Consumption of Heavy Chemicals in t

Chemical Engineering Industries	Sulphuric Acid	Muriatic Acid	Nitric Acid	Oxalic Acid	Acetic Acid	Salt	Sulphur	Alc
	Short Tons of 50 Deg. Bé.	Short Tons of 20 Deg. Bé.	Short Tons of 36 Deg. Bé.	Lb.	Short Tons of 28 Per Cent	Short Tons	Long Tons	Wine Dena
Heavy chemicals	350,000	53,000	15,000	300,000	5,000	2,500,000	490,000	
Fine chemicals	50,000	32,000	2,500	700,000	25,000	10,000	13,000	30,0
Electrochemicals	25,000	.....	300	.....	.....	125,000	20,000	
Coal byproducts	700,000	.....	.....	.....	.....	.....	.....	
Dyes and coal-tar products	30,000	14,000	5,000	400,000	3,000	300,000	40,000	2,0
Fertilizers and insecticides	2,050,000	.....	900	.....	.....	5,000	275,000	
Petroleum products	1,450,000	.....	.....	.....	.....	.....	1,000	
Rayon and textiles	118,000	25,000	3,000	1,200,000	28,500	40,000	1,000	2,0
Leather	5,000	5,000	.....	200,000	4,000	100,000	.....	2,0
Pulp and paper	500	.....	.....	.....	.....	50,000	260,000	
Rubber	25,000	.....	.....	.....	.....	.....	25,000	1,
Soap	5,000	7,000	.....	.....	.....	100,000	.....	
Wood chemicals	10,000	3,000	.....	.....	.....	.....	.....	
Food products	2,000	7,000	.....	.....	.....	4,150,000	3,000	1,
Paint and varnish	200,000	2,000	16,000	.....	10,000	.....	1,000	7,
Explosives	185,000	.....	107,000	.....	.....	.....	65,000	5,
Oils and fats	10,000	3,000	.....	.....	.....	10,000	.....	
Glue and gelatin	2,000	30,000	.....	.....	.....	.....	.....	
Glass and ceramics	500	5,000	.....	.....	.....	50,000	.....	
Percentage used:								
By chemical engineering industries	74.5	80.9	97.9	40.0	96.4	66.3	97.5	
By all other industries	25.5	19.1	2.1	60.0	3.6	33.7	2.5	
Total domestic consumption	7,000,000	230,000	153,000	7,000,000	78,500	7,300,000	1,228,000	105

oilcloth and chemical industries. Of other commodities showing low percentages, there is lime (30.4 per cent) which is largely used in construction and agriculture, alum (40.0 per cent) the largest use for which is in water purification, and oxalic acid which is sold principally to laundries but with substantial uses in metal polishes and miscellaneous applications outside of the chemical engineering industrial market. It is significant that the chemicals which are used in largest proportion by the process group are distributed to a comparatively small number of industries.

From an economic viewpoint the importance of the close inter-relation of these industries lies in the opportunity it offers for consolidations or operating arrangements between non-competing and complementary plants. The community of economic interest and the free interchange of raw materials, intermediates and even finished products which is possible in such large industrial organizations eliminate much of the waste chargeable to distribution and sales competition.

From a purely technical viewpoint the common interest of these industries in the basic heavy chemicals makes possible a certain pooling of research and technical information that leads to economies in both production

...in the Chemical Engineering Industries

Chemical and Metallurgical Engineering
September, 1927

Alcohol	Alum	Ammonia	Arsenic	Liquid Chlorine	Soda Ash	Caustic Soda	Bichromate of Soda	Nitrate of Soda	Silicate of Soda	Sulphate of Soda	Zinc Oxide	Lime
Wine Gals. of Denatured	Tons $Al_2(SO_4)_3$	Net Tons of Nitrogen	Short Tons	Short Tons	Short Tons	Short Tons	Short Tons	Long Tons	Short Tons of 40 Deg. Bé.	Short Tons	Short Tons	Short Tons
.....	12,000	5,000	.....	1,000	150,000	70,000	200	100,000	2,000	97,000	3,500	250,000
30,000,000	500	1,000	350	10,000	30,000	10,000	.....	10,000	.....	1,000	500	50,000
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	35,000
.....	.....	.....	.....	.....	500	3,000	.....	.....	.....	.....	.....	30,000
2,000,000	1,000	1,000	150	2,000	10,000	7,000	500	.....	.....	20,000	.....	10,000
.....	.....	54,000	14,000	.....	.....	.....	.....	660,000	1,000	.....	.....	15,000
.....	.....	100	.....	500	40,000	57,000	.....	.....	.....	.....	.....	3,000
2,000,000	5,000	750	.....	9,750	35,000	85,500	5,100	.....	8,000	92,000	9,000	5,000
2,000,000	500	.....	.....	.....	2,000	1,000	11,600	.....	.....	.....	.....	60,000
.....	100,000	.....	.....	32,500	75,000	9,000	.....	.....	10,000	103,000	.....	330,000
1,500,000	.....	.....	.....	.....	.....	17,000	.....	.....	.....	.....	78,000	3,000
500,000	.....	250	.....	.....	200,000	112,000	.....	.....	83,000	2,000	500	40,000
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10,000
1,500,000	500	.....	.....	.....	500	.....	.....	5,000	.....	.....	.....	20,000
7,500,000	750	.....	.....	.....	1,000	.....	3,400	.....	.....	.....	.....	5,000
5,000,000	.....	7,500	.....	.....	500	.....	.....	275,000	2,000	.....	78,000	.....
.....	200	.....	.....	.....	.....	14,500	.....	.....	.....	.....	.....	6,000
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7,000
.....	250	.....	3,500	.....	585,000	.....	.....	500	2,000	45,000	2,500	500,000
49.5	40.0	66.3	81.8	85.7	83.6	85.7	95.8	95.5	29.8	96.0	98.3	30.4
50.5	60.0	33.7	18.1	14.3	16.4	14.3	4.2	4.5	70.2	4.0	1.7	69.6
105,000,000	300,000	105,000	22,000	65,000	1,355,000	450,000	21,700	1,100,000	375,000	375,000	175,000	4,500,000

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and consumption. When maker and user speak the same technical language and have the same knowledge of the properties and behavior of products, reasonable specifications can be written and contracts drawn on a basis of mutual advantage and understanding.

But it is from the commercial viewpoint that most advantage arises. The chemical engineering group offers a concentrated market for heavy chemicals since the industries that produce these products are themselves the largest consumers. Furthermore, it is the technical man responsible for the quantity and quality of production that must determine the strength, purity and performance of the chemicals used in his manufacturing process. Very often these considerations as well as price and availability are just as important as process and equipment in determining the ultimate yield and, therefore, profit in a manufacturing operation. It behooves the chemical engineer to study the marketing of the chemical products he uses as well as those he produces. Likewise it is to the advantage of the chemical manufacturer to appreciate the fact that the chemical engineering industries offer him his largest market, but one that must be intelligently served on the basis of quality and efficient performance.

Steady Gain in Chemical Production

Total Output Has Nearly Doubled in Last Decade

MEASURED by the indexes of production computed by the Bureau of the Census from quantitative production statistics, the domestic output of chemicals and allied products in 1925 was practically double that reached in 1914, the index number for 1914 being 71 and the 1925 number being 141. Data compiled for the census years from 1914 to 1925 show that the volume of production was continuously advancing with the exception of 1921 when the depression in general business caused a temporary setback. By 1923 manufacturing operations in the chemical and allied industries had reached record proportions. The progressive movement did not cease, however, as may be seen from the following comparison of activities in 1923 and 1925:

Activities in Chemical and Allied Industries 1923-1925

	No. of Establishments	Number Employed	Cost of Materials	Value of Products
1925.....	8,867	380,595	$4,180,411,000	$6,430,027,000
1923.....	8,832	384,493	3,680,407,000	5,706,866,000

Under the classification as given above, the paint and varnish, fertilizer, and explosives industries are included. Hence the percentages of gain as reported for the entire group cannot be regarded as accurately portraying the comparative status of chemical manufacture in the years enumerated. A fairly accurate line on the increase in the output of chemicals may be obtained, however, by tracing the progress of the basic chemical, sulphuric acid. Domestic production, expressed in terms of 50 deg. acid, amounted to 4,071,566 tons in 1914. Of this total it is estimated that slightly more than 2,700,000 tons was produced in the chemical industry with the balancing figure representing operations of fertilizer manufacturers. In 1925 more than 5,000,000 tons of the total production was accredited to chemical manufacturers. According to this calculation the percentage of gain in manufacture of chemicals fell but little below that reported for the combined group of chemicals and allied products. Comparison of the amounts available for domestic consumption of some of the more important chemicals are found in the accompanying table.

Accurate statistics are not available relative to domestic production of chemicals in 1926 but trade estimates indicate that the total exceeded that for 1925, and consequently established a record for the industry. Private estimates on activities for the first eight months of 1927 place production of chemicals as practically on a par with that for the corresponding period of the preceding year.

Domestic Consumption of Specific Chemicals

	Domestic Production	Imports	Exports	Domestic Consumption
Sulphuric Acid				
1925, ton	7,012,328	18,191	3,768	7,026,751
1923, ton	6,555,517	11,754	4,122	6,563,149
Caustic Soda				
1925, ton	497,261	35	50,477	446,819
1923, ton	436,619	59	57,342	379,336
Soda Ash				
1925, ton	1,907,791	130	16,190	1,891,731
1923, ton	1,707,987	765	14,512	1,694,240
Acetic Acid				
1925, ton	32,755	1,773	328	34,200
1923, ton	31,066	135	382	30,819
Liquid Chlorine				
1925, ton	83,163	.....	.....	83,163
1923, ton	62,680	.....	.....	62,680
Alums				
1925, ton	306,405	828	20,756	286,477
1923, ton	249,094	1,375	17,745	232,724
Borax				
1925, ton	49,967	2,240	16,944	35,253
1923, ton	53,092	958	20,300	33,750
Sodium Silicate (Basic 40°)				
1925, ton	394,824	.....	20,258	.....
1923, ton	331,309	525	16,551	315,283
Arsenic, White				
1925, ton	11,438	9,316	.....	20,754
1923, ton	14,696	10,575	.....	25,271
Copper Sulphate				
1925, ton	15,814	902	3,069	13,647
1923, ton	16,152	5,042	1,494	19,700

WHILE an enlargement in consuming outlets for chemicals would follow as a logical sequence of our national growth it is evident that this would not account for the marked gains recorded in the last decade. Analysis of such staple articles as food and clothing reveals an increase in production and consumption which harmonizes closely with the growth in population. In the case of chemicals in addition to this natural increment there has been a marked gain in the per capita consumption of finished products in the manufacture of which chemicals are necessary raw materials. The rapid growth in automobile manufacture has been reflected in increased demand for chemical products in the tire industry, in oil refining, in varnishes and lacquers, in artificial leather, and in various other ways. The newly established rayon industry quickly attained a place of importance among consumers of chemicals. These are typical of tendencies in industrial development which have resulted in broadening the producing and consuming branches of the chemical industry.

Developments within the chemical industry in recent years have been in keeping with the progress reported for production and sales. The fact that the number of workers was smaller in 1925 than in 1923 gives evidence of the improvement in processes and equipment and of the more complete mechanization of operations. Research work has aided greatly in the recent progress of the industry.

Chem. & Met. Weighted Index of Chemical Prices

Base = 100 for 1913-14

This month	**112.55**
Last month	112.35
September, 1926	113.59
September, 1925	112.84

Price changes were irregular with declines in lead and tin salts and methanol, while higher selling schedules went into effect for sulphate of ammonia, arsenic and denatured alcohol. Alkalies and heavy acids were firm with no quotable change in prices. The net change in the weighted index was in favor of higher average values.

Chem. & Met. Weighted Index of Prices for Oils and Fats

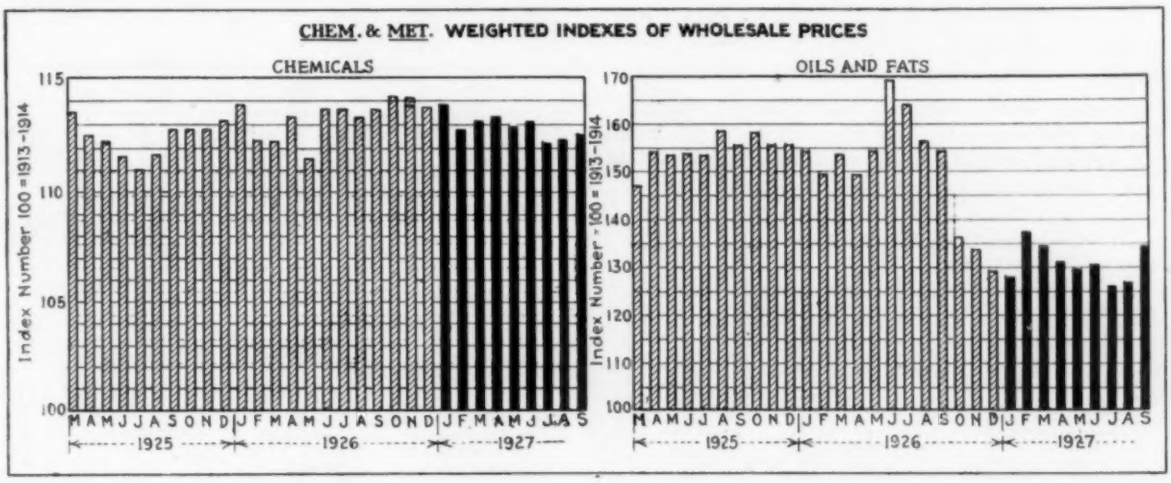
Base = 100 for 1913-14

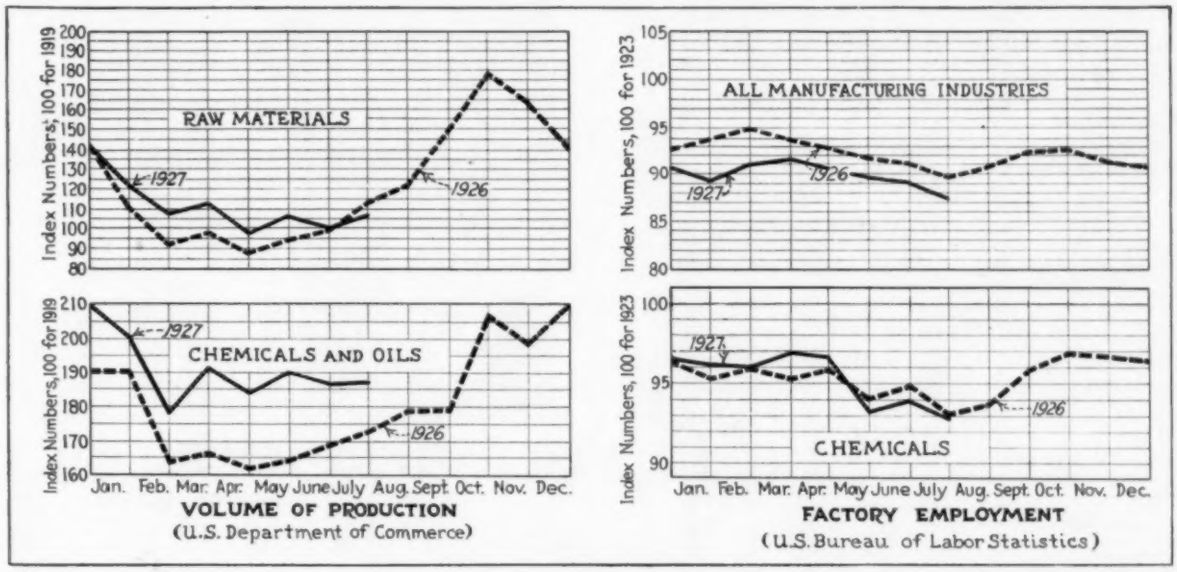
This month	**134.48**
Last month	126.96
September, 1926	154.26
September, 1925	156.04

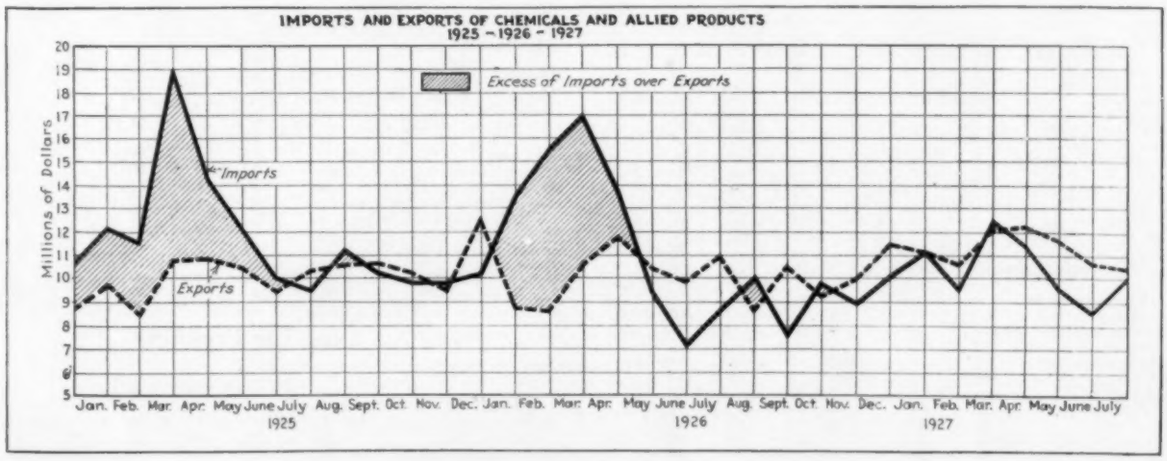
Two refining companies are reported as owning the greater part of old crop cottonseed oil and are offering sparingly. New crop oil is very firm and advancing. With the exception of linseed, castor and palm, other vegetable oils have advanced in price. Higher markets also rule for animal fats with strong markets predicted for the next three months.

CHEM. & MET. STATISTICS OF BUSINESS

IN THE CHEMICAL ENGINEERING INDUSTRIES


CHEM. & MET. WEIGHTED INDEXES OF WHOLESALE PRICES
CHEMICALS
OILS AND FATS
Index Number 100 = 1913-1914
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1925
1926
1927




IMPORTS AND EXPORTS OF CHEMICALS AND ALLIED PRODUCTS
1925 - 1926 - 1927
Excess of Imports over Exports
Imports
Exports
Millions of Dollars
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July
1925
1926
1927

CURRENT PRICES *in the* NEW YORK MARKET

For Chemicals, Oils and Allied Products

The following prices refer to round lots in the New York Market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to September 12.

Industrial Chemicals

		Current Price	Last Month	Last Year
Acetone, drums	lb.	$0.12 -$0.13	$0.12 -$0.13	$0.12 -$0.13
Acid, acetic, 28%, bbl.	cwt.	3.38 - 3.63	3.38 - 3.63	3.25 - 3.50
Boric, bbl.	lb.	.08½- .08¾	.08½- .08¾	.08½- .11
Citric, kegs	lb.	.44½- .45	.44½- .45	.45 - .47
Formic, bbl.	lb.	.11 - .12	.10¾- .11	.10¾- .11
Gallic, tech., bbl.	lb.	.50 - .55	.50 - .55	.45 - .50
Hydrofluoric 30% carb.	lb.	.06 - .07	.06 - .07	.06 - .07
Lactic, 44%, tech., light, bbl.	lb.	.13½- .14	.13½- .14	.13½- .14
22%, tech., light, bbl.	lb.	.06½- .07	.06½- .07	.06½- .07
Muriatic, 18°, tanks	cwt.	.85 - .90	.85 - .90	.85 - .90
Nitric, 36°, carboys	cwt.	.05 - .05½	.05 - .05½	.05 - .05½
Oleum, tanks, wks.	ton	18.00 -20.00	18.00 -20.00	18.00- 20.00
Oxalic, crystals, bbl.	lb.	.11 - .11¼	.11 - .11¼	.10½- .11
Phosphoric, tech., c'bys.	lb.	.07 - .07½	.07 - .07½	.07 - .07½
Sulphuric, 60°, tanks	ton	10.50 -11.00	10.50 -11.00	10.50 -11.00
Tannic, tech., bbl	lb.	.35 - .40	.35 - .40	.35 - .40
Tartaric, powd., bbl.	lb.	.37 - .37½	.37 - .37½	.29 - .30
Tungstic, bbl.	lb.	1.00 - 1.20	1.00 - 1.20	1.00 - 1.20
Alcohol, ethyl, 190 p'f. U.S.P. bbl	gal.	3.75 - 4.00	3.75 - 4.00	4.85 - 4.90
Alcohol, Butyl, dr.	lb.	.19 - .20½	.19½- .20½	.18½- .19
Denatured, 190 proof No. 1 special dr	gal.	.48 -	.47½	.31 -
No. 5, 188 proof, dr.	gal.	.48 -	.44	.31 - .32
Alum, ammonia, lump, bbl	lb.	.03½- .04	.03½- .04	.03½- .04
Chrome, bbl.	lb.	.05½- .05¾	.05½- .05¾	.05½- .06
Potash, lump, bbl.	lb.	.02½- .03¼	.02½- .03¼	.02½- .03¼
Aluminum sulphate, com., bags	cwt.	1.40 - 1.45	1.40 - 1.45	1.40 - 1.45
Iron free, bg	cwt.	2.00 - 2.10	2.00 - 2.10	2.40 - 2.45
Aqua ammonia, 26°, drums	lb.	.02½- .03	.02½- .03¼	.03¼- .04
Ammonia, anhydrous, cyl.	lb.	.11 - .13	.11 - .15	.13 - .15
Ammonium carbonate, powd. tech., casks	lb.	.10½- .14	.10½- .14	.11 - .14
Sulphate, wks.	cwt.	2.25 -	2.25 -	2.50 -
Amylacetate tech., drums	gal.	2.15 - 2.20	2.15 - 2.20	1.80 - 1.90
Antimony Oxide, bbl.	lb.	.16 - .16½	.16 - .17½	.14½- .15
Arsenic, white, powd., bbl.	lb.	.04 - .04½	.03½- .04½	.03½- .04½
Red, powd., kegs	lb.	.09½- .10	.09½- .10	.11 - .12
Barium carbonate, bbl.	ton	50.00 -52.00	50.00 -52.00	48.00 -50.00
Chloride, bbl.	ton	58.00 -60.00	58.00 -60.00	63.00 -65.00
Nitrate, cask	lb.	.08 - .08½	.08 - .08½	.07½- .08
Blanc fixe, dry, bbl.	lb.	.04 - .04½	.04 - .04½	.04 - .04½
Bleaching powder, f.o.b., wks., drums	cwt.	2.00 - 2.10	2.00 - 2.10	2.00 - 2.10
Borax, bbl.	lb.	.04½- .04¾	.04½- .05	.05 - .05½
Bromine, cs.	lb.	.45 - .47	.45 - .47	.45 - .47
Calsium acetate, bags	cwt.	3.50 -	3.50 -	3.25 - 3.50
Arsenate, dr.	lb.	.07½- .08	.07½- .08	.07½- .08
Carbide drums	lb.	.05 - .06	.05 - .06	.05 - .06
Chloride, fused, dr., wks.	ton	21.00 -	21.00 -	21.00 -
Phosphate, bbl.	lb.	.07 - .07½	.07 - .07½	.07 - .07½
Carbon bisulphide, drums	lb.	.05½- .06	.05½- .06	.05½- .06
Tetrachloride drums	lb.	.06½- .07	.06½- .07	.06½- .07
Chlorine, liquid, tanks, wks.	lb.	.04 - .04½	.04 - .04½	.04 - .04½
Cylinders	lb.	.05½- .08	.05¼- .08	.05½- .08
Cobalt oxide, cans	lb.	2.00 - 2.10	2.00 - 2.10	2.10 - 2.25
Copperas, bgs., f.o.b. wks.	ton	14.00 -17.00	14.00- 17.00	13.00 -15.00
Copper carbonate, bbl.	lb.	.16½- .17½	.17 - .18	.16½- .17
Cyanide, tech., bbl.	lb.	.49 - .50	.49 - .50	.49 - .50
Sulphate, bbl.	cwt.	5.00 - 5.10	4.90 - 5.00	4.90 - 5.00
Cream of tartar, bbl.	lb.	.27½- .28	.27½- .28	.21 - .22
Epsom salt, dom., tech., bbl.,	cwt.	1.75 - 2.15	1.75 - 2.00	1.75 - 2.00
Imp., tech., bags	cwt.	1.15 - 1.25	1.15 - 1.25	1.35 - 1.40
Ethyl acetate, 85% drums	gal.	.74 - .76	.74 - .76	.74 - .76
99%, dr.	gal.	.95 - .96	.95 - .96	.98 - 1.04
Formaldehyde, 40%, bbl.	lb.	.11½- .11¾	.11½- .11¾	.09 - .09½
Furfural, dr.	lb.	.15 - .17½	.15 - .17½	.15 - .17
Fusel oil, crude, drums	gal.	1.30 - 1.40	1.30 - 1.40	1.40 - 1.50
Refined, dr	gal.	2.50 - 3.00	2.50 - 3.00	2.50 - 3.00
Glaubers salt, bags	cwt.	1.00 - 1.15	1.00 - 1.10	1.20 - 1.40
Glycerine, e.p., drums, extra	lb.	.23 - .24	.23 - .24	.30 -
Lead: White, basic carbonate, dry, casks	lb.	.09 -	.09 -	.10½-
White, basic sulphate, sck.	lb.	.08½-	.08½-	.09¼-
Red, dry, sck.	lb.	.10 -	.10½-	.12 -
Lead acetate, white crys., bbl.	lb.	.13 - .13½	.13 - .13½	.14½-
Lead arsenate, powd., bbl.	lb.	.12 - .13	.12 - .13	.14 - .15
Lime, chem., bulk	ton	8.50 -	8.50 -	8.50 -
Litharge, pwd., csk.	lb.	.09 -	.09½-	.11½-
Lithopone, bags	lb.	.05½- .06	.05½- .06	.05½- .06½
Magnesium carb., tech., bags	lb.	.07½- .08	.07½- .08	.06½- .06¾
Methanol, 95%, dr.	gal.	.55 -	.55 -	.70 - .72
97%, dr.	gal.	.55 -	.55 -	.72 - .74
Nickel salt, double, bbl.	lb.	.10 - .10½	.10 - .10½	.09 - .10
Single, bbl.	lb.	.10½- .11	.10½- .11	.10 - .11
Orange mineral, csk.	lb.	.12 -	.12½-	.14 -
Phosphorus, red, cases	lb.	.62 - .65	.62 - .65	.65 - .68
Yellow, cases	lb.	.32 - .33	.32 - .34	.33 - .34
Potassium bichromate, casks	lb.	.08½- .08¾	.08½- .08¾	.08½- .08¾
Carbonate, 80-85%, calc., csk.	lb	.05½- .06	.05½- .06	.06 - .06½
Chlorate, powd.	lb.	.08½- .09	.08½- .09	.08½- .09
Cyanide, cs.	lb.	.55 - .57	.55 - .58	.55 - .57
First sorts, csk.	lb.	.09 - .09½	.08½- .09	.08½- .09
Hydroxide(c'stic potash)	dr. lb.	.07½- .07¾	.07½- .07¾	.07½- .07½
Muriate, 80% bgs.	ton	36.40 -	36.40 -	34.90 -
Nitrate, bbl.	lb.	.06 - .06½	.06 - .06½	.06 - .07½
Permanganate, drums	lb.	.14 - .15	.14 - .15	.14½- .15
Prussiate, yellow, casks	lb.	.18½- .19	.18½- .19	.18 - .19
Sal ammoniac, white, casks	lb.	.05½- .06	.05½- .06½	.05½- .06
Salsoda, bbl.	cwt.	.90 - .95	.90 - .95	.90 - .95
Salt cake, bulk	ton	17.00 -18.00	17.00 -18.00	17.00 -19.00
Soda ash, light, 58%, bags, contract	cwt.	1.32½-	1.32½-	1.38 -
Dense, bags	cwt.	1.37½-	1.37½- 1.55	1.45 - 1.55
Soda, caustic, 76%, solid, drums, contract	cwt.	3.00 -	3.00 -	3.10 -
Acetate, works, bbl.	lb.	.04½- .05½	.04½- .05	.04½- .05
Bicarbonate, bbl.	cwt.	2.00 - 2.25	2.00 - 2.25	2.00 - 2.25
Bichromate, casks	lb.	.06½- .06¾	.06½- .06½	.06½- .06¾
Bisulphate, bulk	ton	5.00 - 5.50	5.00 - 5.50	6.00 - 7.00
Bisulphite, bbl.	lb.	.03½- .04	.03½- .04	.03½- .04
Chlorate, kegs	lb.	.06½- .06¾	.06½- .06¾	.06½- .06¾
Chloride, tech.	ton	12.00 -14.75	12.00- 14.75	12.00 -14.00
Cyanide, cases, dom.	lb.	.18 - .22	.18 - .22	.19 - .22
Fluoride, bbl.	lb.	.08½- .09	.08½- .09	.08½- .09
Hyposulphite, bbl.	lb.	2.50 - 3.00	2.50 - 3.00	2.65 - 3.00
Nitrate, bags	cwt.	2.25 -	2 50 -	2.36 -
Nitrite, casks	lb.	.08½- .08¾	.08½- .08¾	.08½- .09
Phosphate, dibasic, bbl.	lb.	.03½- .03¾	.03½- .03¾	.03½- .03¾
Prussiate, yel. drums	lb.	.12 - .12½	.12 - .12½	.10 - .10½
Silicate (30°, drums)	cwt.	.75 - 1.15	.75 - 1.15	.75 - 1.15
Sulphide, fused, 60-62%, dr.	lb.	.03¾- .04	.03½- .04	.02½- .03
Sulphite, crys., bbl.	lb.	.03 - .03½	.03 - .03¼	.02½- .03
Strontium nitrate, bbl.	lb.	.08½- .09	.08½- .09	.08½- .09
Sulphur, crude at mine, bulk	ton	19.00 -	19.00 -	19.00 -20.00
Chloride, dr.	lb.	.04 - .05	.04 - .05	.05 - .05½
Dioxide, cyl.	lb.	.09 - .10	.09 - .10	.09 - .10
Flour, bag	cwt.	2.70 - 3.00	2.70 - 3.00	2.70 - 3.00
Tin bichloride, bbl.	lb.	.19 -	.18½-	.19 -
Oxide, bbl.	lb.	.66 -	.67 -	.67 -
Crystals, bbl.	lb.	.44½-	.45 -	.45½-
Zinc chloride, gran., bbl.	lb.	.06½- .06¾	.06½- .06¾	.07 - .07½
Carbonate, bbl.	lb.	.10 - .11	.10 - .10½	.10½- .11
Cyanide, dr.	lb.	.40 - .41	.40 - .41	.40 - .41
Dust, bbl.	lb.	.09 - .10	.10½- .11	.09 - .10
Zinc oxide, lead free, bag.	lb.	.06½-	.06½-	.07½-
5% lead sulphate, bags	lb.	.06½-	.06½-	.07½-
Sulphate, bbl.	cwt	2.75 - 3.00	2.75 - 3.00	2.75 - 3.00

Oils and Fats

		Current Price	Last Month	Last Year
Castor oil, No. 3, bbl.	lb.	$0.12½-$0.13	$0.12½-$0.13	$0.12½-$0.13
Chinawood oil, bbl.	lb.	.17½-	.17 -	.17½-
Coconut oil, Ceylon, tanks, N. Y.	lb.	.08½-	.08½-	.10 -
Corn oil crude, tanks, (f.o.b. mill)	lb.	.09½-	.11 -	.13 -
Cottonseed oil, crude (f.o.b. mill), tanks	lb.	.10 -	.08½-	nom. -
Linseed oil, raw, car lots, bbl.	lb.	10.4 -	10.8 -	11 3 -
Palm, Lagos, casks	lb.	.07½- .08	.07½- .08	.08½-
Niger, casks	lb.	.07½-	.07½- .07¾	.08½-
Palm Kernel, bbl.	lb.	.08½-	.08½-	.10½-
Peanut oil, crude, tanks(mill)	lb.	.11 -	.12½-	.13½-
Perilla, bbl	lb.	-	-	-
Rapeseed oil, refined, bbl.	gal	.78 - .80	.78 - .80	.84 - .86
Sesame, bbl.	lb.	-	-	-
Soya bean tank (f.o.b. Coast)	lb.	.09½-	.09½-	.10¼-
Sulphur(olive foots), bbl.	lb	.08½-	.08½-	.08¾-
Cod, Newfoundland, bbl	gal.	.63 - .62	.63 - .64	.60 - .65
Menhaden, light pressed, bbl.	gal.	.60 - .66	.60 - .62	.65 - .68
Crude, tanks(f.o.b. factory)	gal	.45 -	.41 -	.47½-
Whale, crude, tanks	lb.	-	-	-
Grease, yellow, loose	lb.	.06½-	.06½-	.08½-
Oleo stearine	lb.	.08½-	.10½-	.12½-
Red oil, distilled, d.p. bbl.	lb.	.09½- .09¾	.09½- .10	.10 - .10½
Tallow, extra, loose	lb.	.08 -	.07½-	.08½-

Coal-Tar Products

		Current Price	Last Month	Last Year
Alpha-naphthol, crude, bbl.	lb.	$0.60 -$0.65	$0.60 -$0.65	$0.60 -$0.62
Refined, bbl	lb.	.85 - .90	.85 - .90	.85 - .90
Alpha-naphthylamine, bbl.	lb.	.35 - .36	.35 - .36	.35 - .36
Aniline oil, drums, extra	lb.	.15 - .16	.15 - .16	.16 - .16½
Aniline salts, bbl.	lb.	.24 - .25	.24 - .25	.22 - .23
Anthracene, 80%, drums	lb.	.60 - .65	.60 - .65	.60 - .65

Coal Tar Products (Continued)

		Current Price	Last Month	Last Year
Benzaldehyde, U.S.P., dr.	lb.	$1.15 -$1.25	$1.15 -$1.35	$1.30 -$1.35
Benzidine base, bbl.	lb.	.70 - .72	.70 - .75	.72 - .74
Benzoic acid, U.S.P., kgs.	lb.	.58 - .60	.58 - .60	.56 - .60
Benzyl chloride, tech, dr.	lb.	.25 - .26	.25 - .26	.25 - .26
Benzol, 90%, tanks, works	gal.	.24 - .25	.24 - .25	.25 - .26
Beta-naphthol, tech., drums	lb.	.22 - .24	.22 - .24	.22 - .24
Cresol, U.S.P., dr.	lb.	.18 - .20	.18 - .20	.18 - .20
Cresylic acid, 97%, dr., wks	gal.	.61 - .62	.61 - .62	.60 - .65
Diethylaniline, dr.	lb.	.58 - .60	.58 - .60	.58 - .60
Dinitrophenol, bbl.	lb.	.31 - .35	.31 - .33	.31 - .35
Dinitrotoluen, bbl.	lb.	.17 - .18	.17 - .18	.18 - .20
Dip oil, 25% dr.	gal.	.28 - .30	.28 - .30	.28 - .30
Diphenylamine, bbl.	lb.	.45 - .47	.45 - .47	.48 - .50
H-acid, bbl.	lb.	.63 - .65	.63 - .65	.65 - .66
Naphthalene, flake, bbl.	lb.	.04½- .05	.04½- .05	.06½- .07
Nitrobenzene, dr.	lb.	.09 - .10	.09 - .10	.09 - .10
Para-nitraniline, bbl.	lb.	.52 - .53	.52 - .53	.50 - .53
Para-nitrotoluine, bbl.	lb.	.28 - .32	.28 - .32	.40 - .42
Phenol, U.S.P., drums	lb.	.18 - .19	.18 - .19	.22 - .24
Picric acid, bbl.	lb.	.30 - .40	.30 - .40	.25 - .26
Pyridine, dr.	lb.	3.00 -	3.00 -	3.90 - 4.00
R-salt, bbl.	lb.	.47 - .50	.47 - .50	.50 - .55
Resorcinal, tech, kegs.	lb.	1.30 - 1.35	1.35 - 1.40	1.30 - 1.40
Salicylic acid, tech., bbl.	lb.	.30 - .32	.30 - .32	.32 - .33
Solvent naphtha, w.w.,tanks	gal.	.35 -	.35 -	.35 -
Tolidine, bbl.	lb.	.95 - .95	.95 - .96	.90 - .95
Toluene, tanks, works	gal.	.35 -	.35 -	.35 -
Xylene, com., tanks	gal.	.36 - .41	.36 - .41	.36 - .40

Miscellaneous

		Current Price	Last Month	Last Year
Barytes, grd., white, bbl.	ton	$23.00-$25.00	$23.00-$25.00	$23.00-$25.00
Casein, tech., bbl.	lb.	.17 - .18	.17 - .18	.17½- .18
China clay, dom.,f.o.b. mine	ton	10.00 -20.00	10.00 -20.00	10.00 -20.00
Dry colors:				
Carbon gas, black (wks.)	lb.	.06½- .07	.06½- .07	.08 - .08½
Prussian blue, bbl	lb.	.33 - .34	.33 - .34	.32 - .33
Ultramine blue, bbl.	lb.	.08 - .35	.08 - .35	.08 - .35
Chrome green, bbl.	lb.	.27 - .31	.27 - .30	.28 - .30
Carmine red, tins	lb.	5.50 - 5.75	5.50 - 5.75	5.10 - 5.85
Para toner	lb.	.80 - .90	.80 - .90	.90 - .95
Vermilion, English, bbl.	lb.	1.80 - 1.85	1.80 - 1.85	1.45 - 1.50
Chrome yellow, C. P., bbl.	lb.	.17 - .18	.17 - .18	.17½- .18
Feldspar, No. 1 (f.o.b. N. C.)	ton	5.75 - 7.00	5.75 - 7.00	6.00 - 6.50
Graphite, Ceylon, lump, bbl	lb.	.07½- .08	.07½- .09½	.09 - .10
Gum copal, Congo, bags	lb.	.09½- .10	.09½- .10	.09½- .10
Manila, bags	lb.	.15 - .18	.15 - .16	.14 - .10
Damar, Batavia, cases	lb.	.25 - .25½	.25 - .26	.25 - .25
Kauri, No. 1 cases	lb.	.55 - .57	.55 - .57	.58 - .62
Kieselguhr (f.o.b. N. Y.)	ton	50.00 -55.00	50.00 -55.00	50.00 -55.00
Magnesite, calc.	ton	44.00 -	44.00 -	38.00 -42.00
Pumice stone, lump, bbl.	lb.	.05 - .07	.05 - .08	.04½- .06
Imported, casks	lb.	.03 - .40	.03 - .40	.03 - .35
Rosin, H.	bbl.	10 25 -	10 90 -	15.40 -
Turpentine	gal.	.57 -	.61 -	.94 -
Shellac, orange, fine, bags	lb.	.54 - .56	.60 - .61	.36 - .38
Bleached, bonedry, bags	lb.	.60 - .63	.67 - .69	.38 - .40
T. N. bags	lb.	.51 - .52	.58 - .59	.34 - .36
Soapstone (f.o.b. Vt.), bags	ton	10.00 -12.00	10 00 -12.00	9.00 -11.00
Talc, 200 mesh (f.o.b. Vt.)	ton	10.50 -	10.50 -	10.50 -
200 mesh (f.o.b. Ga.)	ton	7.50 -10.00	7.50 -10.00	7.50 -11.00
325 mesh (f.o.b. N. Y.)	ton	13.75 -	13.75 -	14.75 -

		Current Price	Last Month	Last Year
Wax, Bayberry, bbl.	lb.	$0.23 -$0.26	$0.23 -$0.26	$0.20 -$0.21
Beeswax, ref., light	lb.	.43 - .45	.43 - .47	.46 - .47
Candelilla, bags	lb.	.38 - .39	.38 - .39	.36 - .37
Carnauba, No. 1, bags	lb.	.57 - .60	.57 - .60	.48 - .50
Paraffine, crude 105-110 m.p.	lb	.05½- .06	.05½- .06	.05½- .06

Ferro-Alloys

		Current Price	Last Month	Last Year
Ferrotitanium, 15-18%	ton	$200.00-	$200.00-	$200.00-
Ferrochromium, 1-2%	lb.	.23- .25	.23- .35	.23-
Ferromanganese, 78-82%	ton	90.00-	90.00-	88.00-90.00
Spiegeleisen, 19-21%	ton	33.00-35.00	33.00-35.00	33.00-34.00
Ferrosilicon, 10-12%	ton	33.00-38.00	33.00-38.00	33.00-38.00
Ferrotungsten, 70-80%	lb.	.95- 1.00	.95- 1.00	1.05- 1.10
Ferro-uranium, 35-50%	lb.	4.50-	4.50-	4.50-
Ferrovanadium, 30-40%	lb.	3.15- 3.75	3.15- 4.00	3.25- 3.75

Non-Ferrous Metals

		Current Price	Last Month	Last Year
Copper, electrolytic	lb.	$0.1331-	$0.1331-	$0.14½-
Aluminum, 96-99%	lb.	.26 -$0.28	.26 -$0.27	.27 -$0.28
Antimony, Chin. and Jap.	lb.	.12 - .12½	.12 - .12½	.15½- .16
Nickel, 99%	lb.	.35 -	.35 -	.35 -
Monel metal, blocks	lb.	.32 - .33	.32 - .33	.32 - .33
Tin, 5-ton lots, Straits	lb.	.63½-	.64½-	.64½-
Lead, New York, spot	lb.	6.25 -	6.75 -	8.40 -
Zinc, New York, spot	lb.	6.60 -	6.70 -	7.65 -
Silver, commercial	oz.	.57½-	.57½-	.63½-
Cadmium	lb.	.60 -	.60 -	.60 -
Bismuth, ton lots	lb.	2.20 - 2.25	2.20 - 2.25	2.70 - 2.75
Cobalt	lb.	2.50 -	2.50 -	3.00
Magnesium, ingots, 99%	lb.	.75 - .80	.75 - .80	.75 - .80
Platinum, ref.	oz.	86.00-	86.00-	111.00-
Palladium, ref.	oz.	59.00- 65.00	59.00- 63.00	69.00-71.00
Mercury, flask 75 lb.		121.00-	121.00-	99.50-
Tungsten powder	lb.	1.05- 1.15	1.05-	1.10-

Ores and Semi-finished Products

		Current Price	Last Month	Last Year
Bauxite, crushed, wks.	ton	$5.50- $8.50	$5.50- $8.50	$5.50- $8.75
Chrome ore, c.f. post.	ton	22.00- 24.00	22.00- 24.00	22.00- 23.00
Coke, fdry., f.o.b. ovens	ton	3.75- 4.25	3.75- 4.25	3.75- 4.25
Fluorspar, gravel, f.o.b. Ill.	ton	17.00- 18.00	17.00-	18.00-
Ilmenite, 52% TiO_2, Va.	lb.	.0½- .0¾	.0½ - .0¾	.01½-
Manganese ore, 50% Mn., c.i.f. Atlantic Ports	unit	.36 - .38	.36 - .38	.40 - .42
Molybdenite, 85% MoS_2 per lb. MoS_2, N. Y.	lb.	.48 - .50	.48 - .50	.65- .70
Monazite, 6% of ThO_2	ton	120.00-	120.00-	120.00-
Pyrites, Span. fines, c.i.f.	unit	.13½-	.13½-	.13½-
Rutile, 94-96% TiO_2	lb.	.11 - .13	.11 - .13	.12 - .15
Tungsten, scheelite, 60% WO_3 and over	unit	11.25 -11.50	11.25 -11.50	12.50 -13.00
Vanadium ore, per lb. V_2O_5	lb.	.25 - .28	.25 - .30	.30 - .35
Zircon, 99%	lb.	.03 -	.03 -	.03 -

CURRENT INDUSTRIAL DEVELOPMENTS

New Construction and Machinery Requirements

Aluminum Plant—Leyse Aluminum Co., A. Leyse, Mgr., Kewaunee, Wis., is receiving bids for the construction of a 2 story, 56 x 97 ft. aluminum plant. Private plans.

Ammonia Distillation Plant—The Empire Gas & Electric Co., Geneva, N. Y., plans the installation of a complete ammonia distillation plant, 7,000 gal. of weak liquor daily capacity. Somet-Solvay Engineering Corp., 40 Rector St., New York, is engineer.

Atomized Fuel Plant — Atomized Fuel Corp., 20 North Twelfth St., Fort Dodge, Ia., is having preliminary plans prepared for the construction of an atomized fuel plant. Estimated cost $80,000. Private plans. Machinery and equipment will be required.

Bleachery—Cannon Mfg. Co., Kannapolis, N. C., awarded contract for the construction of a bleachery to W. O. Pratt, Mount Holly, N. C. Estimated cost $250,000.

Brass Factory—Higgins Brass Mfg. Co., 12435 Dequindre St., Detroit, Mich., had plans prepared for the construction of a 1 story, 80 x 200 ft. brass factory. G. V. Pottle, 1801 David Whitney Bldg., Detroit, Mich., is architect. Equipment for the manufacture of brass products will be required.

Canning Plant—Gebhardt Chili Powder Co., San Antonio, Tex., awarded contract for the construction of a 2 story canning plant to L. T. Wright & Co., 908 Builders Exchange Bldg., San Antonio. Estimated cost $100,000.

Carbon Black Plant—Kosmos Carbon Co., Borger, Tex., subsidiary of Columbian Carbon Co., 45 East 42nd St., New York, N. Y., is having plans prepared for the construction of a carbon black plant at Borger, Tex. Estimated cost $200,000. Private plans.

Cement Plant—Ideal Cement Co., C. Boettcher, Pres., Denver, Colo., will build a cement plant, 2,500 bbl. daily capacity at White Cliffs, Ark., by day labor. Estimated cost $2,000,000. Private plans. Work will be done under the supervision of M. C. Mathews, Ada, Okla.

Cement Plant—The Pennsylvania-Dixie Cement Corp., Nazareth, Pa., awarded contract for a group of 28 silos for cement plant to Turner Construction Co., Buffalo, N. Y.

Centrifugal Separators—The Lee Engineering & Construction Co. Ltd., J. S. Lee, Pres., Exchange Bldg., St. John's, N. F., prices and catalogs on centrifugal separators to separate oil from residue from digesters.

Chemical Plant—Halsey Bros. Co., 645 St. Clair St., manufacturing chemists, awarded contract for the construction of a 4 story, 65 x 117 ft. chemical factory. Estimated cost $100,000.

Chemical Plant — Naugatuck Chemical Co., Elm St., Naugatuck, Conn., awarded contract for the construction of a 1 story, 45 x 170 ft. chemical plant to W. J. Megin Co., 51 Elm St., Naugatuck, Conn. Estimated cost $20,000.

Chemical Plant — Richards Chemical Works, 190 Warren St., Jersey City, N. J., awarded contract for the construction of a 2 story, 100 x 200 ft. chemical plant at Warren and Essex Sts. to James Billington, 198 Fairmount Ave., Jersey City, N. J. Estimated cost $100,000.

Chemical Plant — Winehaven Chemical Co., 433 California St., San Francisco, Calif., is having preliminary plans prepared for the construction of a chemical plant at Richmond, Calif. Estimated cost including equipment, $300,000. O. Krenz Copper & Brass Works, 4th and Bryant Sts., San Francisco, Calif., is architect.

Cider Mill and Fruit Canning Factory—J. E. Rich, Main St., Marlboro, Mass., awarded contract for the construction of a 1 story cider mill and fruit canning factory on Northboro Rd. to T. LePage, 80 Florence St., Marlboro, Mass. Estimated cost $40,000.

Concentrating Plant—Abana Mines Ltd., 205 St. James St., Montreal, Que., c/o

Williams-Broehn & Co., 466 St. Francois Xavier St., Montreal, Que., plans the construction of a concentrating plant, 250 ton capacity.

Condensed (Milk) Plant—Pet. Milk Co., Arcade Bldg., St. Louis, Mo., is having preliminary plans prepared for the construction of a condensed (milk) plant at Kosciusmo, Miss. Estimated cost $500,000. Private plans. Work will probably be done by owner's forces.

Confectionery Factory—M. W. Fisher, c/o W. Lowe, 354 Hobart St., Oakland, Calif., Archt., will soon award contract for the construction of a 3 story candy factory at 10th and Howard Sts., San Francisco, Calif. Estimated cost including equipment $275,000. G. Haas & Son., Phelan Bldg., San Francisco, Calif., lessee.

Cotton Oil Mill—Big Bend Cotton Oil Co., J. M. Duke, Mgr., Marfa, Tex., plans the construction of a cold press cottonseed cake and cotton oil mill, 18 ton capacity. Estimated cost $18,000.

Cotton Oil Mill—P. A. Morris, Ada, Okla., has acquired the Honey Grove Cotton Oil Co.'s plant at Honey Grove, Tex. and is having surveys made for extensions and improvements. Estimated cost $40,000. Private plans. Machinery will be required.

Distillery—Sarnia Cognac & Distilling Co., Sarnia, Ont., plans extensions and improvements to distillery. Estimated cost $500,000. Engineer not selected.

Dye Factory—New Staten Island Dye Works, 16 Harvey St., New Brunswick, N. J., will build a 2 story, 100 x 100 ft. dye factory. Estimated cost $40,000. H. Bach, 63 Schureman Ave., New Brunswick, N. J., is architect. Work will be done by separate contracts.

Enamel Products Plant—A. Weiskittel & Son Co., Lombard and 12th Sts., Baltimore, Md., will build a 1 story, addition to plant for the manufacture of stoves, furnaces, enamelware, etc. Estimated cost $100,000.

Enameling and Stamping Plant—National Enameling and Stamping Co., 1901-1919 Light St., Baltimore, Md., plans the construction of a 1 story, 88 x 180 ft. addition to plant at Johnson and Winder Sts.

Fertilizer Plant—Virginia-Carolina Chemical Co., Shreveport, La., has work under way for the remodeling of fertilizer plant. Estimated cost $75,000.

Glass Factory—Phillips Co., Oshawa, Ont., will soon award contract for the construction of a 1 story, 100 x 150 ft. addition to glass factory on Front St. Estimated cost $40,000. Equipment will be required.

Glass Plant—Pine Glass Co., Okmulgee, Okla., awarded contract for the construction of a 1 story, 80 x 170 ft. gas plant to Muskogee Iron Works Co., Frankfort and Spaulding Sts., Muskogee, Okla. Estimated cost $80,000. A battery of twenty glass ovens and blowers will be required.

Glass Plant Addition—Graham Glass Co., Evansville, Ind., awarded contract for the construction of a 1 story, 160 x 250 ft. addition to glass plant to Rust Engineering Co., 311 Ross St., Pittsburgh, Pa. Estimated cost $150,000.

Insulator Plant—Insulator Corp., Charles and Cromwell Sts., Baltimore, Md., manufacturers of electric porcelain insulators, etc., will build a 32 x 70 ft. building for clay working equipment also 40 x 60 ft. building for press room, etc.

Kilns—Alberta Lumber Co. Ltd., 790 6th Ave. W. Vancouver, B. C., will build six 12 x 120 ft. dry kilns on False Creek by day labor. Estimated cost $50,000. Private plans.

Laboratory—State of Connecticut, F. L. Salmon, State House, Storrs, Conn., will soon receive bids for the construction of a 3 story laboratory building at Connecticut Agricultural College. Estimated cost $354,000. D. K. Perry, 17 Court St., New Britain, is architect.

Laboratory Equipment—Buick Motor Car Co., Flint, Mich., is in the market for laboratory equipment for proposed 4 story, 80 x 210 ft. engineering building on Industrial Ave. Estimated cost $200,000.

Laboratories—St. Anthony's Sanatarium, Amarillo, Tex., is having plans prepared for the construction of a 5 story 100 x 150 ft. hospital including laboratories on North Polk St. Estimated cost $500,000. W. C. Hedrick, Ft. Worth, Tex., is architect.

Laboratories—St. Thomas Seminary, M. F. McAuliffe, West Hartford, Conn., will soon award contract for the construction of a 3 story, 60 x 480 and 40 x 160 ft. seminary including laboratories etc. on Bloomfield Rd. Estimated cost $1,000,000. L. A. Walsh, 51 Leavenworth St., Waterbury, Conn., is architect.

Lacquer Factory—Egyptian Lacquer Mfg. Co., c/o M. M. Marston, Douglas Bldg., Los Angeles, Calif., will soon award contract for the construction of a 1 story, 50 x 50 ft. lacquer factory at South Maple Ave, Los Angeles, Calif.

Lacquer Factory—H. V. Walker, 17 John St., New York, N. Y., awarded contract for the construction of two 1 and 3 story lacquer factory buildings at Division St., Elizabeth, N. J., to Wilhelms Construction Co., 119 Division St., Elizabeth, N. J. Estimated cost $40,000.

Lamp Factory—Tung-Sol Lamp Works Inc., 95 8th Ave., Newark, N. J., plans the construction of addition to lamp factory, at High St. and 7th Ave. Estimated cost $60,000. Architect not selected.

Leather Factory—A. G. Walton, 108 Main St., Wakefield, Mass., awarded contract for the construction of a 1 story addition to leather plant to C. Doyle, Jordan Ave., Wakefield, Mass.

Packing Plant — Wyandotte-Canneries Inc., Oroville, Calif., awarded contract for the construction of a 1 story packing plant including vat and drying rooms, etc. to J. L. Fry, Oroville, Calif. Estimated cost $24,650.

Paint Factory—Boydell Bros. White Lead & Color Co., 432 East Lafayette St., Detroit, Mich., plans the construction of a 1 story paint factory on Cardoni St. Estimated cost $100,000. Halpin & Jewell, 1024 Hammond Bldg., are architects. Mechanical equipment for the manufacture of paints and colors will be required.

Paint Factory—Steel & Abbott, 287 Main St., Gloucester, Mass., will build a paint factory on Wharf St. Private plans. Work will be done by separate contracts.

Paint and Varnish Factory—Armstrong Paint & Varnish Works, 1342 South Kilbourn Ave., Chicago, Ill., awarded contract for the construction of a 1 story, 64 x 86 ft. warehouse for paint and varnish factory. Estimated cost $32,000.

Paint and Varnish Factory — Farboil Paint Co., Eastern Ave. and 11th St., Baltimore, Md., will build additional plant buildings for the manufacture of paints, varnishes, enamels, lacquers, etc.

Paper Mill—American Reinforced Paper Co., County St., Attleboro, Mass., is receiving bids for the construction of a 1 story paper mill on Starkey Ave. Estimated cost $50,000. C. T. Main, 201 Devonshire St., Boston, Mass., is architect.

Paper Mill—J. Lapalosa, 177 Remsen Ave., New Brunswick, N. J., will build a 2 story paper mill. Estimated cost $40,000. H. G. Bach, 63 Schureman Ave., New Brunswick, N. J., is architect. Work will be done by separate contracts.

Paper Mill—Warren Mfg. Co., 342 Madison Ave., New York, N. Y., awarded contract for the design and construction of addition to paper mill at Milford, N. J. to H. K. Ferguson Co., Hanna Bldg., Cleveland, O. Estimated cost $300,000.

Paperboard Mill—Canadian Paperboard Co., H. O. 2 Leigneurs St., Montreal, Que., will receive bids in October for the construction of a paperboard mill including beater building, engine building, pump room, etc. at Toronto, Ont. Estimated cost $500,000. Kerry & Chace, Ltd., Confederation Life Bldg., Toronto, Ont., are engineers.

Pottery Addition—H. A. Weller, Pottery, Zanesville, O., awarded contract for the construction of a 1 and 3 story, 167 x 330 ft. addition to pottery to The Austin Co., Union Trust Bldg., Pittsburgh, Pa. Estimated cost $300,000.

Pulp and Paper Mill—Zellerbach Paper Corp., 1254 First St. S., Seattle, Wash., plans the construction of a pulp and paper mill, initial capacity, 150 ton at Port Townsend, Wash. Estimated cost approximately $4,000,000. Baar & Cunningham, Spaulding Bldg., Portland, Ore., are engineers.

Pulverizer Factory—American Pulverizer Co., E. E. Elzemeyer, Pres., 18th and Austin Sts., St. Louis, Mo., awarded contract for the construction of a 2 story, 79 x 140 ft. factory for the manufacture of pulverizing machinery at 1319 Macklind St. to W. C. Harting Construction Co., International Life Bldg., St. Louis, Mo.

Rayon Mill—Dupont Rayon Co., Wilmington, Del., will build third unit of rayon plant at Old Hickory, Tenn. Estimated cost $4,000,000. Dupont Engineering Co., Dupont Bldg., Wilmington, Del., is engineer. Work will be done by day labor.

Raw Brass Factory — Stamford Rolling Mills, Springdale, Conn., plans to rebuild mill for the manufacture of raw brass recently destroyed by fire, 1 story, 112 x 215 ft. Estimated cost $40,000. Fletcher-Thompson, Inc., 542 Fairfield Ave., Bridgeport, Conn., are architects.

Refinery—San Angelo Refining Co., R. W. Humes, V. Pres., San Angelo, Tex., is having preliminary plans prepared for the construction of a new refinery. Estimated cost $100,000. Private plans.

Refinery (Oil)—J. B. Evans, Beaumont, Tex., has acquired the Yuba Oil Refining Co's. plant at Nacogdoches, Tex. and plans the installation of additional machinery and equipment. Estimated $50,000.

Rubber Factory Equipment—Guelph Rubber Products Co., M. Eunushevsky, Mgr., 49 Gordon St., Guelph, Ont., prices and catalogs on equipment for the manufacture of rubber boots, auto tire patches and general rubber products for proposed new rubber factory. Estimated cost $25,000.

Rubber Plant — Aetna Rubber Co., Ashtabula, O., plans the construction of a rubber plant at Ashtabula or Cleveland, O. Estimated cost $50,000.

Rubber Plant—Firestone Tire & Rubber Co. of Canada, Ltd., Hamilton, Ont., is having plans prepared for the construction of a 2 story, 260 x 280 ft. rubber plant. Estimated cost $250,000. Hutton & Sauter, 6 James St. S., Hamilton, Ont., are architects.

Rubber Plant—Cambridge Rubber Co., 948 Main St., Cambridge, Mass., awarded contract for the construction of a 5 story, 75 x 95 ft. addition to rubber plant on Main St. to The Sculley Co., 238 Main St., Cambridge, Mass.

Rubber Plant — Canadian Goodrich Co. Ltd., 36 St. Geno St., Montreal, Que., will soon award contract for the construction of a 3 or 4 story, 200 x 250 ft. addition to rubber factory on King St. W. Estimated cost $150,000. Kitchener, Ont. Equipment will be required.

Rubber Plant—Sun Rubber Co., Barberton, O., awarded contract for the construction of a 1 story 60 x 70 ft. rubber plant on Mack Rd. to Austin Co., 16112 Euclid Ave., Cleveland, O. Estimated cost $40,000.

Silk Dying and Finishing Plant—Diamond Silk Dying & Finishing Co., 690 Johnson Pl., West New York, N. J., awarded contract for the construction of a 1 story, 100 x 100 ft. silk dying and finishing plant to Auf Du Heide Construction Co., 443 16th St., West New York, N. J. Estimated cost $50,000.

Silk Factory—William Messmer Silk Co., 223 Hackensack Plankroad, Weehawken, N. J., is having plans prepared for the construction of a 2 story silk factory at North Bergen, N. J. Estimated cost $40,000. Private plans.

Silk Factory—Schwarzenbac-Huber Inc., 511 23rd St., Union City, N. J., awarded contract for the construction of a 3 story, 70 x 90 ft. silk factory to Wigton-Abbott Corp., 552 West 23rd St., New York, N. Y. Estimated cost $75,000.

Smelting Plant—The River Smelting & Refining Co., 4195 Bradley Rd., Cleveland, O., awarded contract for the construction of a 1 story, 48 x 56 ft. smelting plant to Griffin-Zimmerman Co., Engineers Bldg., Cleveland, O. Estimated cost $40,000.

Storage Battery Plant — Prest-O-Lite Co., 30 East 42nd St., New York, N. Y., awarded contract for the construction of a 2 and 3 story plant at Dallas, Tex. to P. O. B. Montgomery, 808½ Commerce St., Dallas, Tex. Estimated cost $200,000.

Soap Manufacturing Plant—S. O. C. Chemical Co., Panhandle, Tex., is having preliminary surveys made for the construction of a 2 story soap manufacturing plant at Wichita Falls, Tex. Estimated cost $60,000. Private plans.

Varnish Factory—Ohio Varnish Co., 9001 Kinsman Rd., Cleveland, O., awarded contract for the construction of a 1 and 2 story, 55 x 70 ft. varnish factory to J. L. Hunting Construction Co., Guarantee Title Bldg., Cleveland, O. Estimated cost $40,000.

Wallboard Plant—Certain-teed Products Co., 100 East 42nd St., New York, N. Y., is having preliminary plans and surveys made for extensions and improvements to wallboard plant for the manufacture of plaster from rock including considerable machinery at Acme, Tex. Estimated cost $70,000. Private plans.